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THE BALANCE OF TECHNOLOGICAL AND TECHNICAL MAN-POWER

THE need for balancing the claims of defence research against the competing claims on Britain's limited resources of man-power, as well as the way in which the size of the Armed Services themselves inevitably affects the man-power available for industry in general, is well brought out in the White Paper on Defence (see *Nature*, April 7, p. 635). The decision to reduce the man-power in the Forces to about seven hundred thousand by March 1958, as announced last October, is intended to provide some relief to the man-power situation as well as to the national economy. While, however, the numerical demand for man-power by the Services may be thus slightly reduced, the premium on skilled man-power, particularly the highly skilled long-service regular service-man, is increased. The improvements in pay in the Armed Services which have recently been announced are intended to increase the numbers of men signing on for, or converting to, long-service engagements and to reduce the wastage of man-power that is unavoidable with a rapid turnover of short-time regulars.

In this respect the Government has thus made a direct attempt to secure the more effective utilization of the man-power of Britain, and particularly skilled man-power; but the elimination of waste in this field has by no means received the attention which it demands. Indeed, the emphasis now being placed on the expansion of technical and technological education sometimes obscures the truth that such measures—even if there were no shortages of science or technical teachers, of buildings or equipment to cause delay in implementing plans—take a term of years to fructify. There are no short cuts or quick returns in educational development; and apart from relieving a particular shortage by measures which merely drain the supply from other demands and create or intensify other shortages, the real hope for the short-term alleviation of the man-power situation lies in the more effective use of the resources already at our disposal.

Some of those possibilities were well indicated in the proceedings of a Conference on the Utilization of Scientific Professional Manpower held at Columbia University, New York, in October 1953, and which have since been published*. The report appears to have received little notice in Britain, although it indicates questions to which answers are urgently required in Britain if man-power resources are to be wisely handled, and indeed if the resources now to be devoted to technical and technological education are to be expended to the best advantage, from the point of view of the nation and from that of the students themselves. For example, the recent White Paper on Technical Education assumes that five or six technicians may be required for each technologist. This, however, is a ratio which will vary from one occupation or profession to another. If we are to take account of it in planning the expansion of technical and technological education, we need to have more accurate information as to this ratio and as to the relative numbers engaged in the different occupations and professions.

Nor is this all. We need to assure ourselves that the ratio of technician to technologist or professional worker is a reasonable one in the circumstances of to-day, and not one determined purely by professional tradition or conditions which are no longer relevant. For its elucidation of this point alone and for its indication of the possibilities in saving the time of the highly skilled professional worker as a result of careful re-examination of practice in medicine, in engineering and in teaching alone, the proceedings of the Columbia University Conference merit consideration by all concerned with the more efficient utilization of scientific and technical man-power in Britain. We cannot afford to allow questions of either professional status or practice to hinder the fuller use of supporting technicians when this can be done without detriment to professional standards and the quality of the service.

This question of the ratio of technicians to technologists thus opens up larger issues. We need to ask the reasons for these ratios, why they should vary from industry to industry, from profession to profession, or even from plant to plant within an industry. The answers to such questions will often throw light on the ways in which the less highly trained workers could be used to support and increase the efficiency of those fully trained, and may indeed suggest new ways in which the existing shortages of scientists and technologists could be ameliorated by making use of those with much less training.

This is only the first of six major approaches to the more effective utilization of scientific and professional man-power suggested at the Conference. Another is that adopted by the British Government in the new schemes of pay for the Armed Services, in so far as these provide incentives to prevent the wasteful turnover of professional trained personnel. This is a field in which industry, by giving more attention to the selection and placing of its recruits, could probably do even more to reduce wastage; but more still will be done if, in the new plans for the expansion of technical and technological education in Britain, due attention is given to encouraging adaptability and adequate breadth of education, as indeed the White Paper recognizes.

Another major approach specified at the Conference was the re-assessment of the appropriateness of the education and training of professional persons; and this point is one that is of especial importance in considering the expansion of technical education in Britain. Even when full account is taken of the importance of encouraging adaptability, the effective utilization of scientific and technical man-power always depends on the way in which professional

* National Manpower Council. Proceedings of a Conference on the Utilization of Scientific and Professional Manpower. Held October 7–11, 1953, at Arden House, Harriman Campus of Columbia University. Pp. xii+197. (New York: Columbia University Press, 1954.) 3 dollars 50 cents.

education and training are related to the functions which those so trained are expected to perform. This is one reason why the syllabuses for professional examinations as well as the curricula of technical colleges and universities require continual re-appraisal in the changing world of to-day. Moreover, if wise decisions are to be made, the conception of the purpose of technological and of technical education, as well as of university education, must be clear and sound.

The development of new patterns of work to improve the total output of professional workers and technicians in concert is another major approach which demands fresh minds and constructive thinking, as well as a good deal of investigation. It could well prove a most fruitful field of investigation by the joint committees of the Department of Scientific and Industrial Research and the Medical Research Council, and some of the possibilities in this direction were indicated by the Secretary of State for Air in presenting the Air Estimates on March 5. Another major approach suggested is the increased use of capital to permit the full employment of professional skill. This is an approach which, apart from capital considerations, is clearly more difficult to explore in Britain than in the United States. Under certain conditions, additional expenditure on buildings or equipment may well increase the output of goods or services from the same number of technologists or scientists. It will not, however, be sufficient to secure their co-operation alone: the fear of redundancy must be dispelled from the minds of those who work with them, and unless this is done the capital expenditure may merely increase the cost of the goods or services without any advantage.

The sixth direction in which the Conference at Columbia University looked for the more efficient utilization of scientific and technical man-power was through improved leadership and administration. This aspect, however, in respect of research was discussed even more fully at the ninth annual conference on the administration of research held last September at the Northwestern University Technological Institute, Illinois*. The pattern of organization in the United States differs considerably from that in Britain, and some of the criticism of that pattern which was expressed at the Conference has not the same validity elsewhere. There may, for example, be less risk in Britain that research activities at the universities will be expanded in ways inimical to teaching or the real purposes of a university: sponsored research and ear-marked grants are scrutinized too carefully, and it should not be too difficult, with the existing organization rightly used, to ensure that fundamental research is pursued on a reasonably even front.

The comments on security and freedom of communication are another matter and touch as closely on the effective utilization of trained man-power in Britain as in the United States. In both countries intimate and rapid communication as well as secrecy and caution are needed in pushing back the frontiers of knowledge in other fields besides that of nuclear energy. The practical problem is to provide the necessary minimum of security around the research and development programmes in the military field without hindering the degree of communication vital to the maximum stimulation of inventive thinking and the effective application of results. To over-emphasize security is inconsistent with the effective prosecution of research, and is a continual cause of wasted man-power.

Again, waste of man-power in research easily arises out of administration which lacks full understanding of the outlook and methods of the research worker. The task of the administrator, even in applied research, consists not merely in selecting the problems but also in providing the conditions which are most stimulating for creative work. Criticisms on this point made in the United States by Mr. P. P. Barnard apply more particularly to defence research; but they have their implications for Britain also, and suggest ways in which the efficiency of such research might possibly be increased by securing greater co-operation on the part of industry.

The criticism by business executives of the administration of research in the United States is of particular interest. Expenditure there on research is estimated at some 4,500 million dollars for the year ending June 30, 1956, of which about 2,000 million dollars will be spent by industry and another 1,000 million dollars on government contracts with industry for defence purposes. The magnitude and variety of such contracts have been severely criticized, as well as the widespread invitations to tender and the tendency on the part of some government agencies in the United States to treat research as a commodity. These were all criticized as wasteful of effort, and waste also arises in the administration of contracts, primarily from the lack of understanding already noted, while secrecy can lead to serious duplication of effort by different departments and organizations. Generally it was considered that industrial research is cheaper than that administered by the Government, and this is a factor which suggests that the effort of the central government should be kept to the minimum that security and like considerations suggest.

From the point of view of the efficient utilization of scientific and technical man-power in Britain, if not of other resources, the distribution of research effort should be determined largely by the appropriateness of the projects for the type of institution. Universities, government departments and research institutions, private research institutions and those of the public corporations and of private industry all have their particular or even special competence, advantage of which must be taken if the nation's resources are to be deployed to the best advantage; nor will this need disappear even when educational developments begin to overtake the shortage of scientific and technical man-power. Merely increasing the number of those who receive technical education will not solve this problem of making full use of creative man-power. It will still be essential to

* Proceedings of the Ninth Annual Conference on the Administration of Research, September 7–9, 1955, Northwestern University Technological Institute, Evanston, Illinois, U.S.A. Pp. 107. (University Series.) (New York: New York University Press, 1956.) 4 dollars.

apportion those resources of scientific and technological man-power where they are most needed and can be most effective.

Much of this question of securing more efficient utilization of scientific and technical man-power consists essentially in the prosaic work of making small adjustments here and there, so as to improve the relations between government departments or between such departments and industry, or those between the administrator and the research worker. The principles laid down by the Atomic Energy Commission of the United States in relation to its research programme deserve, however, to be noted and applied widely at a time when fundamental research is of growing importance to military and economic security alike. The university is still an unmatched source of fundamental knowledge, and progress in research comes most rapidly when the individual scientist is free to follow the dictates of his own scientific curiosity and reasoning, without pressure from those who seek possible practical application of his findings. Moreover, the most significant progress in fundamental research is achieved by a relatively few outstanding individuals. The emphasis on a research programme should accordingly be on the effective support of selected men rather than of institutions, and the universities which produce these men should be supported in programmes that can be integrated properly with their educational function. It should be remembered, too, that the individual scientist is the best judge of what research effort will lead to the most significant progress in fundamental science; and it should also be recognized that a programme for the expansion of technical and technological education which fails to take due account of all such considerations is very unlikely to yield the maximum return for its expenditure.

THE CHEMISTRY OF CELLULOSE

Cellulose and Cellulose Derivatives

Prepared under the Editorship of Emil Ott, Harold M. Spurlin and Mildred W. Grafflin. Second completely revised and augmented edition. (High Polymers Series: a Series of Monographs on the Chemistry, Physics and Technology of High Polymeric Substances—Vol. 5.) Part 1, pp. xvi+509; Part 2, pp. viii+511–1056; Part 3, pp. viii+1057–1601.

(New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1954–55.) 12 dollars each part.

KNOWLEDGE of the chemistry of high polymers has grown so rapidly that it is difficult for the student of to-day to realize that only thirty years ago cellulose was generally regarded as a colloid of the micellar aggregate type based on a comparatively simple unit containing at most a few glucose residues. Even the X-ray crystallographic results were interpreted as providing supporting evidence for this view. New ideas on the possibility of a covalent bond structure for large molecules were provided by the pioneering work of Staudinger, and in 1926 Sponsler and Dore suggested a formula for cellulose in which the molecule was represented as a long chain of consecutively linked glucose residues. This particular structure could not be reconciled with the detailed chemistry of cellulose, and the one now generally accepted, which postulates a long unbranched chain of β-1,4′-linked D-glucopyranose residues, was then put forward by Haworth. Detailed interpretations of the X-ray data on the new basis were given by Meyer and Mark, and to some chemists it appeared that the problems of the structural chemistry of cellulose had been solved. Nevertheless, those whose business it was to deal with industrial applications of cellulose remained dissatisfied, feeling that many of the details which gave the substance its special properties were beyond the range of the available chemical and physical methods of investigation.

To some extent subsequent work on the organization of cotton cellulose, wood cellulose and regenerated cellulose into crystalline regions alternating with less highly ordered portions helped to explain the reactivity of the various celluloses. Much also was discovered which helped to explain the distinctive properties of the oxycelluloses and hydrocellulose. But little was known of the organization of the macromolecules in the region between the single chains revealed by chemical investigation and the relatively gross structural features visible under the ordinary microscope. Only recently has a beginning been made in this field by means of electron microscope studies carried out notably by workers of the Swedish school. Evidence of a complex fibrillar structure comprising bundles of individual cellulose molecules is now coming to light, and although it is perhaps too early to say that anything like a complete picture can yet be presented, it is significant that this recent work tends to bring us back again to the idea of a colloid which depends largely on hydrogen bonds for the preservation of its fine structure. Further work on these lines and on the infra-red spectroscopy of cellulose fibres will be awaited with much interest. Many other fundamental and industrially important problems still await solution, including the nature of the association of cellulose, hemicelluloses and lignin as they occur in lignified plant tissues.

In the meantime, however, the reader will find in the three books under review authoritative accounts of the present state of knowledge in these fields of fundamental scientific study. He will find also detailed discussions of all aspects of the technology of cellulose and its derivatives. The formidable task of revising the 1943 edition in the light of the many subsequent discoveries has been most successfully undertaken by the editors and their two dozen collaborators. Despite the number of authors, the various sections of the book are well balanced and the presentation is remarkably even.

The first part is concerned mainly with the fundamental scientific background, with chapters on the occurrence of cellulose, its chemical nature, and the structure of cellulose fibres. It concludes with a section on the nature of the various substances associated with cellulose in Nature, including brief accounts of lignin, the hemicelluloses and the structure of wood. In Part 2 the subjects considered are more industrial in character. They include the large-scale preparation of cellulose, its bleaching and purification and the special treatments employed in the utilization of wood-pulp for paper-making. There is also a chapter composed of several independent

sections which deal with the esters, ethers, xanthates and other derivatives of cellulose, with valuable discussions on the chemical reactivity of cellulose and on the degradation of its derivatives.

In the first section of the third part there is a return to fundamental considerations, with authoritative and clear accounts of important physical features such as the solubility of cellulose and its derivatives, the thermodynamic properties of these solutions, the problems arising in the determination of molecular weights of macromolecular substances, theories of viscosity for dilute solutions of long-chain compounds, and a discussion of flow properties, including rheological phenomena. Next there is a section on the mechanical properties of cellulose followed by one on tests for cellulose and a series of appendixes in which are gathered together a whole host of data which will be invaluable to all whose work is in the cellulose field. Only those who have experienced it can appreciate fully the difficulty of finding such facts in the immensely scattered literature.

It will be clear from this account that this work is a book of reference rather than a text-book. Much of its usefulness will depend, therefore, on the quality of the indexing. Two indexes are provided at the end of the third book—an author index of forty-one closely printed pages and a subject index of seventy-four similar pages. Like the rest of the book, these are excellently done, and in so far as I have tested them they have been found to be readily usable, comprehensive and accurate. There is no doubt that this will long be regarded as a standard work on the subject, and the editors, authors and publishers are to be congratulated on the completion of this revised and augmented second edition.

E. L. Hirst

MATHEMATICS FOR CHEMISTRY STUDENTS

Mathematics for the Chemist

Mathematical Analysis for Chemists, Physicists and Chemical Engineers. By Prof. G. J. Kynch. Pp. vii+356. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1955.) 30*s*. net.

Prof. G. J. Kynch's book is intended to meet the needs of students taking honours courses in chemistry, to provide a text with emphasis on the applications of mathematics, and to serve as a reference book for practising chemists and biochemists. Although written by a professional mathematician, it aims at being intelligible and useful in its field, and a characteristic is the brief yet reasonably strict nature of the methods used. Many results of integrations are merely stated, but the reader should easily find them by using methods which are explained.

The differential and integral calculus, series, exponential, logarithmic and hyperbolic functions, complex numbers, differential equations, determinants, vectors, Fourier series and spherical harmonics are included. An account of curvilinear co-ordinates and their applications would have been useful and could have taken the place of some of the text on approximate solution of equations and numerical methods. The treatment throughout is clear and interesting, the chapter on series being particularly good, and the book can be strongly recommended. The exercises call for thought rather than use of formulæ, and contain some useful additions to the text. References to books are given at the ends of the chapters. The book may not supply all the needs of users the author has in mind, who will want to know something about contour integrals, matrices and elementary group theory, but it provides a sound basis for future extension of knowledge.

The book is evidently based on teaching experience and a knowledge of the special difficulties of students of chemistry; many matters passed over in purely mathematical books are clearly explained, and cases where errors easily arise are pointed out. It may be suggested, with due deference, that pure mathematicians could with advantage look through the book with reference to their own courses. When the lectures to chemistry students are taken by a junior on the mathematics staff, the book will be of great assistance to him in pointing out the needs of the students and the kind of treatment which is desirable.

NATURE CONSERVATION FOR TEACHERS

Handbook for Teaching of Conservation and Resource-Use

Prepared by the National Conservation Committee of the National Association of Biology Teachers in conjunction with the American Nature Association. (Richard L. Weaver—Project Leader.) Pp. 500. (Danville, Ill.: Interstate Printers and Publishers, Inc., 1955. Obtainable from Project Leader, National Association of Biology Teachers, P.O. Box 2073, Ann Arbor, Mich., U.S.A.) 4 dollars.

A public awareness of the importance of wise use and management of natural resources is highly desirable, particularly in view of the ever-growing demands which increasing world population makes upon them. In the United States the National Association of Biology Teachers has aimed at increasing this awareness by its conservation project, seeking to introduce conservation studies into schools wherever possible. The word conservation is here used in its widest sense—virtually an attitude of mind towards natural resources, akin to that of the ecologist regarding mankind as a biotic factor in the general scheme of Nature.

This book, which has been prepared for teachers, describes all possible methods of teaching conservation, in the class-room, school grounds and the field, sources of help for the teacher from the State and community, and schemes for extending interest in conservation teaching beyond the biology department. The matter is presented as reports, from individual schools, on actual projects which they have carried out. Examples are grouped under such headings as: films, slides and film-strips; radio programmes (the script of a radio skit broadcast by one school is given in full); aquaria and terraria; collection, preparation and exhibition of specimens; nature trails and sanctuaries.

One can find good ideas in these accounts which could be adapted to the rather different organization of teaching in Great Britain, but unfortunately they are buried in such a welter of blatantly obvious detail that one wearies of the search. For example, under

"Field Trip Technique" the reader is told: "If transportation is to be provided . . . every precaution must be taken to guarantee comfort and safety". "Leaders' Responsibility. It is helpful to plan how to keep attention centred on the main objective of the trip. . . . Leaders should speak distinctly enough for all to hear". In describing a particular field excursion, negotiations for hiring the bus are given six lines; and three-quarters of a page is spent on reproducing, in entirety, the letter to parents asking approval for their children to go on the trip, and ensuring that they will be there to meet them on their return. In the same way, many of the photographs are no more than pleasant school groups taken in the field, telling the reader absolutely nothing.

Thus, while fully agreed that the teaching of conservation is a worthy cause, one finds it hard to recommend this book (with its inevitable high price) to teachers outside the United States.

MAURICE ASHBY

PROBABILITY AND STATISTICAL INFERENCE

The Foundations of Statistics

By Prof. Leonard J. Savage. (Wiley Publications in Statistics.) Pp. xv+294. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1954.) 48*s*. net.

MY main objection to this book concerns its title. The first half deals with theories of probability in their subjective and objective aspects; the second half defines "statistics proper" as "the art of dealing with vagueness and with interpersonal difference in decision situations". Some of the words in this definition, perhaps, provide avenues of escape; but as Prof. Savage goes straight into minimax theory, to which seven out of the closing ten chapters are devoted, it is fair to construe his attitude as one which takes statistics to be a theory of decision. This view is not shared by many British statisticians, who rightly insist, first, on the fact that statistical inference is only part of statistics and, second, on the fact that decisions are only part of statistical inference.

As a contributor to the foundations of the theory of decisions, Prof. Savage's book is, however, welcome and stimulating. He cannot subscribe to the frequency theory of probability, but adopts a new approach to the subjective theory by referring it back, like the economists, to a theory of utility. Even here the decision aspect of the subject affects his thinking, but the treatment is interesting and well written.

In founding statistical inference on minimax theory, Prof. Savage starts on the defensive; for the minimax principle, in its crude form, says that we must act as if the worst will happen, which is reasonable enough in games against a clever adversary but is not reasonable against Nature. Prof. Savage, however, extricates himself from this difficulty, not without a struggle, and proceeds to ground which is more familiar to the ordinary statistician by discussing estimation and tests of significance. He has some rather startling things to say about accepted theories on this subject, but what he says is well thought out and deserves attention. It is to be hoped that his criticisms are not lost to sight under the controversy which they may well raise.

M. G. KENDALL

A HANDBOOK FOR MUSEUM CURATORS

The Preservation of Natural History Specimens

Edited and Compiled by Reginald Wagstaffe and Dr. J. Havelock Fidler. Vol. 1: Invertebrates. Pp. xiii+205. (London: H. F. and G. Witherby, Ltd., 1955.) 42*s*. net.

THE intention of this book is to bring together in one place a collection of all those techniques concerned with the preservation of natural history specimens that have proved to be efficacious. In addition to the old and well-tried methods, a considerable amount of original work is included.

The first part of the book consists of a systematic survey of the chief invertebrate groups from the Protozoa to the Tunicata. In each group there is given the method of killing (preceded by narcotization where necessary), of fixing and of preserving. In cases where special manipulation is necessary, this is described and sometimes illustrated with a diagram. For the detailed formulæ in each case the reader is referred to the appropriate section of the appendix. This saves an intolerable amount of repetition.

Clearly, there are groups which lend themselves to fuller treatment than others, and the Insecta are dealt with in considerable detail, particularly as to setting and mounting. One suspects that the beauty of Miss Begg's drawings has beguiled the editors into extending this section a little beyond the limits of necessity. In the section on Echinodermata no mention is made of the corrosive sublimate method of preserving the test, particularly of *Echinus*, recommended by the late R. T. Jackson, of Harvard (see *Mus. J.*, **29**; May 1930). This method preserves both the spines and the lantern and is exceedingly simple to apply. It is also useful in the case of many Crustacea.

It may be noted that throughout the book the emphasis is upon the preservation of the external features. Anatomical dissection and display are not considered.

The second part of the book consists of five appendixes dealing with apparatus and instruments; reagents; labels and labelling; storage; and microscopy. Here there is a large and useful collection of formulæ and recipes, and the description of many pieces of apparatus, both simple and ingenious. Many of them are well known; some of them are new. It is perhaps the most useful section of the book. Among the formulæ for cements for sealing museum jars, the asphalt–guttapercha mixture is recommended, particularly for jars containing formalin, but it is equally effective for 70 per cent alcohol. I have found it quite the best general-purpose cement for museum work. Stitching on to cards is recommended in a number of cases. For wet mounts, stitching on to glass is perhaps the best method, and a later edition might include a simple technique for drilling holes in glass (see *Mus. J.*, **35**; Nov. 1935); or maybe it will appear in Vol. 2.

In a work of reference, the importance of the index is obvious. In this case it performs its job efficiently and with the minimum of irritation. The general format of the book is excellent. The binding is strong, the paper good, the type clear, and Miss Begg's illustrations a real embellishment. The editors are to be congratulated on a very sound job, and one looks forward to the appearance of the second volume.

W. ERIC STONEMAN

Principles and Practice of Field Experimentation

By Dr. John Wishart and Dr. H. G. Sanders. Second edition. (Technical Communication 18 of the Commonwealth Bureau of Plant Breeding and Genetics, Cambridge.) Pp. vii+133. (Farnham Royal: Commonwealth Agricultural Bureaux, 1955.) 21*s*.

THE first edition of this book, published twenty years ago and for a long time out of print, was a landmark in so presenting the statistical outlook on field experimentation that it could be understood and used without advanced training in statistics. A new edition is therefore of considerable interest.

Dr. J. Wishart's section, on statistical principles and techniques, has been extensively revised; the result is an improved and up-to-date version, though the emphasis on expressing yields as percentages and the deletion of any graphical explanation of covariance analysis seem unfortunate. New chapters briefly discuss factorial design, confounding, and incomplete block designs. The author has met the difficulty that his subject has grown to a much greater extent than his few additional pages can contain, so that inevitably his account appears relatively less comprehensive than in the first edition. He is therefore the more to be congratulated on so well combining clear instructions for analysis of simple experiments with laying a sound foundation for further study. The contribution by Dr. H. G. Sanders is a general discussion of the practical aspects of field experiments, ranging from advice on when—and when not—to do experiments to rules for good recording. Changes from the first edition are slight; but the section remains perhaps one of the best published guides to experimental policy and details of field technique.

This book should be in the hands of all who conduct field experiments: they will learn from it much that will help their understanding of how statistical science can assist their work.

D. J. Finney

Le Microscope à Contraste de Phase et le Microscope Interférentiel

Par Maurice Françon. Pp. 150+1 plate. (Paris: Éditions du Centre National de la Recherche Scientifique, 1954.) 1,000 francs.

AFTER reading this book one is left wondering how it is possible to cover the subject so completely in only 125 pages. The answer is that the exposition is so clear and the selection of topics so excellent that scarcely a word is wasted. The only exception is the section on the applications of phase-contrast, which is too short and might be either omitted or expanded in future editions.

The first part of the book deals with general optical theory. After discussing the modification of the Airy disk pattern by aberrations and errors of focus, the formation of images of extended objects by coherent and incoherent light is examined. This is an excellent simple introduction to modern physical optics. The chapter on phase-contrast describes the main optical systems that have been used, including those for variable and coloured phase-contrast. Such questions as the effect of absorption in the phase plate and the resolving power are dealt with, but one could have wished for an account of the defects of the method, particularly the halo effect.

The final chapter is devoted to interference microscopy and is one of the best compilations so far available on this subject. Progress in this field is so rapid that it is sometimes difficult to decide priority. British readers may feel that the work of F. H. Smith does not receive proper acknowledgment, and that some of his designs have been unwittingly re-invented by others. The diagrams are for the most part excellent and a useful bibliography is added. A few minor printing errors were noticed. This is a book which can be read with profit by many and with real pleasure by all interested in optics.

An Introduction to the Calculus of Finite Differences

By Prof. C. H. Richardson. Pp. vi+142. (New York: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1954.) 28*s*. net.

THIRTY years ago, the student of numerical analysis had no English text readily available save the brilliant pioneer work by Whittaker and Robinson, "Calculus of Observations" (1924). Since then the rapid growth of the subject, and the widening field of its applications, have produced many good books in English, some covering the whole field, some with a view to special applications. Prof. Richardson has based his book on a short course for actuaries and statisticians, but the course has also proved of value to electrical engineers and other technicians. The elements of finite differences, on a somewhat formal basis, are expounded in 120 pages: the operators E and Δ; the finite sum, with special reference to the Stirling numbers; the Euler and Bernoulli polynomials; interpolation and numerical integration; the gamma function; and simple difference equations. Only the simplest elements of the infinitesimal calculus are assumed to be known, and arguments are often plausible rather than strictly logical. The book should therefore serve as an outline of methods and problems, preparing the novice for the further study of more substantial treatises on the numerical or theoretical aspects of the difference calculus.

Some Beautiful Indian Trees

By Ethelbert Blatter and Walter Samuel Millard. Second edition, revised by William T. Stearn. Pp. xv+165+78 plates. (Bombay: Bombay Natural History Society; London: Wheldon and Wesley, Ltd., 1954.) Rs. 20; 30*s*. net.

THIS well-known book has been out of print for some considerable time, so now the second edition, edited by Mr. W. T. Stearn, is assured of a hearty welcome. Both the authors of the original book have died; but I feel sure that they would have approved of the way Mr. Stearn has carried out his part of the work, for this is not a mere reprint but an amended, corrected and enlarged account of the beautiful trees to be found in any large city in India. I am particularly glad to see that he has adopted the correct botanical name for the species where a change has become necessary.

The original plates were printed in England by a well-known firm of colour printers and were very well executed. It is not stated where the plates for the second edition were produced; but they are most unworthy of the book—cold, lifeless and falsely coloured.

The statement that there is a live specimen of *Amherstia nebilis* in one of the hot-houses at Kew is, alas, not true. The specimen referred to was lost during the War.

This book can be recommended to anyone who is visiting India.

N. L. Bor

ARTIFICIAL ICE-FORMING NUCLEI

By B. J. MASON and J. HALLETT
Imperial College of Science and Technology, London

THE fact that supercooled clouds commonly occur in the atmosphere at temperatures above −20° C., with the implication that efficient ice-forming nuclei are often deficient, and the possibility of inducing rain by supplying artificial nuclei, stimulated the search for substances which, when dispersed as an aerosol, might produce vast numbers of efficient, durable nuclei. The most important discovery was made by Vonnegut[1] in 1946, who found that when silver iodide smoke was introduced into a supercooled cloud in the laboratory, some ice crystals appeared when the temperature fell below −4° C. and that the numbers increased with decreasing temperature until, at about −15° C., most of the silver iodide particles appeared to serve as ice nuclei. Since one gram of silver iodide in solution could be vaporized to produce about 10^{16} nuclei, large-scale cloud seeding became a practical possibility. The success of silver iodide, which was chosen originally because the lattice constants of the hexagonal form are very similar to those of ice (see Table 1), initiated an intensive search for substances which might be either more efficient or less expensive than silver iodide. Papers have appeared from several different laboratories[1-6] reporting on the ice-nucleating ability of a wide variety of chemical compounds introduced either as smokes, sprays or as fine dusts into a supercooled cloud formed in an expansion- or mixing-cloud chamber. Except in the case of silver iodide, which is generally agreed to be the most effective of all the substances so far tested, the results obtained by the different workers are very conflicting; for example, substances reported as highly effective by one laboratory are found to be completely inactive by another.

We believe that in many of these experiments, spurious results may have resulted from the presence of trace contaminants (particularly silver and iodine) in the air, and of trace impurities in the various chemicals. We therefore decided to carry out very careful tests on those substances which have been reported as producing highly efficient ice nuclei by at least two independent workers. These include: silver iodide, lead iodide, mercuric chloride, silver nitrate, silver sulphate, silver sulphide, lead chloride, sodium chloride, iodine, ammonium iodide, sodium iodide, cadmium iodide, cobalt iodide, mercuric iodide and thallium iodide.

We have found that, if spectroscopically pure materials are used and great care is taken to exclude all traces of iodine and silver from the air in the experimental chamber, the great majority of substances reported as active by other workers fail to produce ice crystals in a supercooled cloud at temperatures above −40° C., when spontaneous nucleation of the supercooled droplets occurs.

That minute particles of silver may react very rapidly with iodine vapour in low concentration to produce particles of silver iodide was noticed by one of us several years ago. On opening a bottle of iodine near an open-top mixing-cloud chamber in which traces of silver aerosol may have remained from a previous experiment, the supercooled cloud became transformed into ice crystals within a few seconds; but iodine failed to produce crystals when introduced into a sealed cloud chamber filled with filtered air. A similar effect may be demonstrated by causing a small electric spark between two thin silver wires in a large flask containing a small iodine crystal; on passing air through the flask into a cloud chamber, the supercooled water cloud may be transformed completely into ice within a few seconds of forming the spark. These experiments suggest that should any silver salt which may either decompose on heating or dissolve inside a droplet be dispersed into a supercooled cloud containing small traces of iodine, particles of silver iodide might be formed and cause the appearance of some ice crystals at high temperatures; a similar result might be expected if an iodide were dispersed in an atmosphere containing traces of silver.

Experimental Procedure

Our nucleation tests were carried out in a modified version of the continuously sensitive diffusion cloud chamber described by Schaefer[7]. The chamber, shown in Fig. 1, consists essentially of a vertical column, 50 cm. high, 30 cm. in diameter, cooled at the bottom and held at or above room temperature at the top, where water is evaporated into the chamber to produce a convectively stable, thermally stratified cloud which, in the absence of ice nuclei, exists in the liquid state above the −40° C. isotherm. The lower plate, supported by a solid aluminium block, is maintained at about −60° C. by surrounding the lower part of the apparatus with 'dry ice'. The top plate, when unheated, remains at about 5 deg. C. below room temperature, and the positions of the 0° C. and −40° C. levels are roughly as indicated in the diagram. A water reservoir, sufficient for several days, is mounted on the underside of the top plate and may be electrically heated. The plane, rectangular walls of the chamber are made of 'Perspex'. A deep cold zone is established by the inner copper walls soldered to the base plate. The outer plate glass walls serve to reduce the lateral inflow of heat and to widen the vertical temperature gradient, which is measured

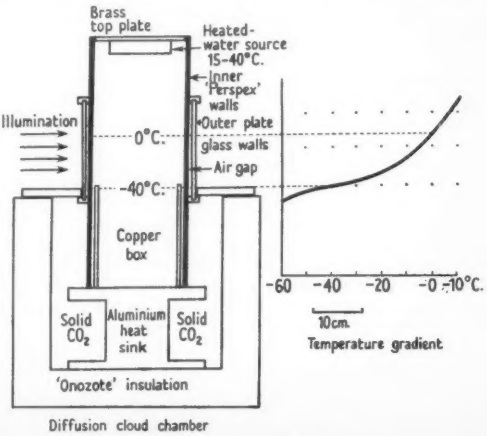

Fig. 1. The diffusion cloud chamber

by a thermocouple attached to a micrometer head. The vertical separation of the 0° C. and −40° C. levels is about 10 cm. A horizontal network of thermocouples serves to check that the horizontal temperature distribution is reasonably uniform.

Before commencing a nucleation test, the chamber is thoroughly cleaned, sealed and left for some hours for any particles present to fall out and leave very clean air in which condensation on the ion-tracks of cosmic rays may be seen. Artificial nuclei are then introduced through valves in the top plate, and their nucleating effects are observed or photographed by viewing normally to an intense beam from a high-pressure mercury lamp passing horizontally through the chamber. Within about one minute of entering the top of the chamber, the nuclei arrive at the 0° C. level, below which one watches for the first appearance of glittering ice crystals, the temperature at this level being measured. The threshold temperature for nucleation will depend upon the quantity of nuclei introduced and the volume of the observational space; but in these tests we adopted the temperature below which more than one ice crystal appeared among about 10^4 water droplets. The nuclei were produced either by spraying a solution or by vaporizing the substance on an electrically heated wire in an atmosphere of clean nitrogen to prevent oxidation effects. Blank tests were always carried out with the heated wire and with distilled water to check that they produced no effective nuclei.

Because particles, having become centres of condensation, take only about 10 sec. to fall between the 0° C. and −40° C. levels in the diffusion chamber, it might be argued that their failure to produce ice crystals at temperatures above −40° C. might be attributed to their having long activation times. To meet this point, simultaneous tests were also made with a large mixing-cloud chamber of capacity 400 litres, where the nuclei were introduced into a continuously generated supercooled cloud and remained in suspension for some minutes. With this arrangement it was possible to detect whether ice crystals were produced at temperatures above −20° C.

Nucleating Ability of Various Chemicals

In early tests, ammonium iodide, potassium iodide, sodium iodide and iodine vaporized on an electrically heated nickel wire all produced ice crystals in the diffusion chamber at temperatures above −20° C., as reported by other workers. But as the particles, being highly soluble, rapidly went into solution when condensation occurred upon them, it was difficult to understand how they could have acted as ice-forming nuclei. Our suspicions that the iodine compounds were reacting with silver or lead impurities in the nickel wire to produce either silver iodide or lead iodide received support when two such wires were sparked in iodine vapour to give large numbers of ice-forming nuclei active at temperatures above −15° C. When the tests were repeated with spectroscopically pure nickel wire, the four above-mentioned substances and also cobalt, mercuric, thallium and stannous iodides did not produce significant numbers of ice crystals at temperatures above −40° C. Similar results were also obtained for sprayed solutions of ammonium, potassium, sodium, cobalt, stannous, magnesium, manganous and nickel iodides and iodine.

The early tests on silver salts (other than silver iodide) did not give consistent results. When smokes or sprays of silver nitrate or sulphate were introduced into a freshly cleaned diffusion chamber, only a very low concentration of ice crystals appeared at first, but the numbers gradually increased, and after about twenty minutes, these salts appeared to have about the same level of activity as silver iodide, with some crystals appearing at about −5° C. and complete glaciation of the cloud occurring at −15° C. Although these results were in accord with those of other workers, it was again difficult to accept them at face value, in view of the high solubility of silver nitrate and silver sulphate. Furthermore, when silver nitrate was sprayed into a large mixing chamber containing supercooled cloud at −20° C., no significant increase in the number of ice crystals occurred. However, on introducing a small iodine crystal for only two seconds, the whole cloud became transformed into ice crystals. This demonstrated, in striking fashion, the influence of small traces of iodine, and we attribute the gradual increase in the number of crystals appearing in the diffusion chamber after the introduction of a silver salt to the slow exudation of iodine adsorbed on the 'Perspex' walls. That minute traces always remained even after the most careful cleaning was demonstrated by sparking two silver wires directly in the chamber; ice crystals appeared at temperatures below −5° C. and were presumably formed upon nuclei of silver iodide. When the silver nitrate was tested in a glass vessel freed completely of iodine by baking, no ice crystals appeared. From these and other tests, we are convinced that silver nitrate and silver sulphate are not capable of nucleating supercooled water, and that they appeared to be highly effective in other experiments[2,4,6] only because they formed silver iodide in the presence of small quantities of iodine.

Our results for lead iodide confirm those of previous workers in finding it to be a very efficient nucleating agent, producing a significant number of ice crystals in both chambers at −7° C. and complete glaciation at −15° C.; it is therefore only slightly less effective than silver iodide. On the other hand, both lead nitrate and lead chloride are found to be inactive in the diffusion chamber, and also in the mixing chamber, at temperatures above −20° C. Deliberate contamination with small quantities of iodine, however, brings about rapid formation of ice crystals, presumably through the production of lead iodide.

In all these experiments the presence of ice crystals is inferred solely from the appearance of glittering particles in an illuminated region of the supercooled cloud. That this may not be an infallible test was indicated by the appearance of such particles in the upper, warm regions of the diffusion chamber when smokes and sprays of mercuric chloride, and finely powdered cupric sulphide, stannous oxide and beryllium oxide were introduced. The glittering of the particles was much reduced once they had fallen several centimetres and become involved in condensation, but in the case of cupric sulphide and mercuric chloride, the scintillation increased again below the −15° C. and −25° C. levels respectively. The collection of the crystals formed at these low temperatures and their observed melting under the microscope suggested that ice crystals were being produced. Since the cupric sulphide was only of commercial grade, further tests, including spectroscopic analyses, are being carried out. But a recent report[6] that finely powdered copper sulphide causes complete glaciation of a supercooled cloud at −6° C. may be questioned; it seems that scintillation of the copper sulphide particles themselves may have been mistaken for the

appearance of ice crystals. In the case of beryllium oxide, no crystals were observed between the 0° C. and − 40° C. levels. Sodium chloride, manganese dioxide, manganese chloride and cadmium sulphide were found to be similarly inactive. Introduction of powdered stannous oxide produced a cloud of glittering particles throughout the whole depth of the chamber.

The only chemical compounds which we have found to be definitely active as ice-forming nuclei at temperatures above −40° C. are silver iodide (−5° C.), lead iodide (−7° C.) and mercuric chloride (−25° C.), the temperatures in brackets indicating the threshold limits of activity.

Behaviour of Silver Iodide Nuclei

Silver iodide is certainly the most effective ice-nucleating substance so far discovered. Its efficiency depends very much, however, upon the method of preparation. In fact it occurs in two crystal forms at room temperature—a hexagonal (wurtzite) arrangement and a cubic (zinc blende) arrangement, the cubic form being regarded as the stable form at temperatures below 135° C. The hexagonal form is the thermodynamically stable one between 135° C. and 146° C. Above 146° C. both types may become transformed into a new high-temperature cubic form. The unit-cell dimensions of the three forms are shown in Table 1.

Table 1

Substance	Crystal form	Unit dimensions (A.)
Silver iodide	Hexagonal (wurtzite)	$a = 4{\cdot}58$, $c = 7{\cdot}49$
	Cubic (zinc blende)	$a = 6{\cdot}47$
	'High temp.' cubic	$a = 5{\cdot}03$
Lead iodide	Hexagonal	$a = 4{\cdot}54$, $c = 6{\cdot}86$
Ice	Hexagonal	$a = 4{\cdot}52$, $c = 7{\cdot}37$

When silver iodide is vaporized at several hundred degrees centigrade, X-ray and electron-diffraction patterns of the smoke show that it consists of a mixture of the hexagonal and cold cubic forms, with some indication of the hexagonal form being more dominant the higher the temperature of the source[8]. Whether the hexagonal or the cubic form provides the more efficient ice nuclei has not yet been established, but it is perhaps worth noting that the atomic array in the (111) planes of the cold cubic structure and the (001) planes of the hexagonal form are geometrically identical, the lattice spacing being 4·58 A. in each case.

Silver iodide generators used in cloud seeding utilize silver iodide dissolved with either sodium or potassium iodide in acetone. The solution is sometimes atomized through a nozzle by compressed hydrogen or propane and the spray ignited; alternatively, it is sprayed into a kerosene flame. Another method is to soak coke nuts in the solution and burn these in a ventilated furnace.

Electron-diffraction patterns, taken at the Imperial College by Lisgarten (unpublished), produced by the vaporization of silver iodide–potassium iodide and silver iodide–sodium iodide mixtures, suggest that these techniques may not be the most efficient. The patterns produced by silver iodide–potassium iodide mixtures show little or no trace of either silver iodide or of potassium iodide but suggest that mixed crystals are being formed (see Fig. 2). The silver iodide–sodium iodide mixtures reveal no trace of hexagonal silver iodide but produce patterns consistent with those of either the cubic form of silver iodide or of sodium iodide, which have an almost identical lattice spacing; alternatively, mixed crystals of both

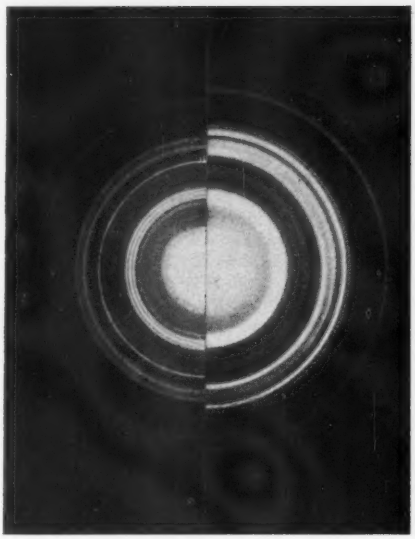

Fig. 2. *Left:* electron-diffraction pattern of a smoke produced by vaporization of a silver iodide–potassium iodide mixture. *Right:* pattern produced by vaporization of silver iodide *in vacuo*. Note that the pattern produced by the mixture shows no rings which can be identified with those of silver iodide. (Photo by N. D. Lisgarten)

substances with unaltered lattice spacing may have been formed. X-ray and electron-diffraction patterns of smokes produced by the vaporization of pure silver iodide crystals include broad, diffuse rings indicative of an amorphous rather than a crystalline structure. It seems that the silver iodide, having become partly decomposed by heating, fails to form good crystals during quenching; certainly electron micrographs show the particles to be malformed, with few well-defined crystalline shapes.

If the silver iodide nuclei are produced in a reducing atmosphere such as will be provided if acetone and particularly hydrogen are burned at high temperatures, their surface layers may be reduced to metallic silver and their ice-nucleating ability largely inhibited. This effect appears to be greatly enhanced if the crystals are irradiated with ultra-violet light (cf. the reduction of silver bromide to metallic silver in a photographic emulsion), which explains why silver iodide may quickly lose its ice-nucleating properties when dispersed into the atmosphere during strong sunshine. According to tests made by Smith, Seely and Heffernan[9] the activity of nuclei from a hydrogen burner decays to about a hundredth of its initial value after an exposure of only 15 min.

The discovery of a method for producing large quantities of highly efficient and durable silver iodide particles is of considerable practical importance. Lead iodide, which is not so susceptible to photolytic decomposition, appears to merit further investigation as a possible substitute.

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THE IMITATION OF MENTALITY*

By Dr. W. GREY WALTER
Burden Neurological Institute, Bristol

DURING the past twenty years, electronic methods have revealed many exciting and useful relations between the patterns of electrical activity in the brain and the temperament, mentality and behaviour of human subjects. These discoveries are acknowledged aids to the diagnosis of brain disorders; but there is still no general theory of normal brain action, nor are there convincing special hypotheses about the relation between the known functions of the brain and thinking. Such theories as have been advanced have been too ambiguous to suggest clear-cut experiments, since their expression in words leaves so much to the imagination. On the other hand, attempts to express notions about the brain in rigorous mathematics are hard for experimentalists to understand. Since the scientific method depends upon the steady development of clear working hypotheses, advances in the understanding of brain function will be slow until this dilemma has been resolved. One method which seems promising is to embody the components of a hypothesis in a working model, observing carefully the rules of parsimony and the test of prediction; the model must contain no redundant parts and is valid only if its behaviour permits prediction of behaviour beyond that originally intended. A model or analogue of this sort is, in fact, a crystallized hypothesis; it should be clear and brittle. When it breaks down, as all working hypotheses must, its failure is obvious and explicit; a verbal hypothesis can yield almost imperceptibly and change its form under the pressure of facts.

From time to time most artificial systems for communication and calculation have been used as models of the brain. Automatic telephones, electronic computers, totalizators have all been invoked in turn to illustrate certain aspects of higher nervous function. None of these, however, serves the purpose, and during the past few years several models have been built specially to illustrate hypothetical mechanisms underlying living behaviour.

The simple concept of reflex action, as defined by Sherrington, is so simple that it scarcely needs illustration; none the less, the feedback principle of error cancellation, which appears so frequently in modern engineering design, is basically a reflex. It is strange that the power of such a system has only recently begun to be appreciated by engineers. The principle of the automatic governor devised by Watt was analysed by Maxwell before the physiology of reflex action had been worked out; but it has taken nearly a century for the advantages of negative feedback to be exploited. Nowadays, a modern home is likely to contain at least half a dozen mechanical reflexes, and motor-cars, ships and aeroplanes would be unmanageable without them. The extra-ordinary properties of the reflexive system are seen clearly only when several elements are capable of free interconnexion with one another. In such a complex system, even if the activity is limited to all-or-none binary responses, the number of patterns of interconnexions is enormous; if the number of modes of connexion be M and the number of elements n, then for values of n greater than 6, M is approximately $2^{(n^2-n)}$. The inferences from this simple relation are encouraging to brain physiologists, who often feel dismayed by the joint challenge of the ten thousand million nerve elements in the human brain and the associated complexity of human mentality. It would be comforting to be able to suppose that the vast congregation of nerve cells in the head might act in large clumps; obviously it will never be possible to consider the individuality of each nerve cell. Yet large numbers are required for any mechanistic hypothesis of mentality. Fortunately, very large numbers can appear from the free intercommunication of a few elements as suggested above. If we must provide a model capable of forming a fresh pattern every tenth of a second for the span of a long lifetime, we must ask how many elements would be necessary. The answer is: six. In other words, an artificial brain with six freely interacting elements could get into more than ten thousand million different states. It is not suggested that the human brain contains only six functional elements; what may be important is that, with the several hundred that have already been identified and named, a variety of character and experience could be generated comparable with what we know of human individuality and versatility.

In order to illustrate what sort of behaviour can be derived from reflexive systems alone, a number of models has been built. These contain only two 'nerve elements' in the form of wireless valves and relays, two sense organs (a simple 'eye' and a skin) and two effectors (a motor for crawling and one for steering). As well as this, it is arranged that the eye shall scan in a circular fashion so that it can distinguish and respond to a light signal wherever this may be. One mode of behaviour is this scanning for signals, the next is the positive response to a moderate light which interrupts the scan and leaves the model facing the light and crawling towards it. Another mode is the avoidance of bright light, another again the circumvention of obstacles when the skin is touched. The behaviour of these models is entirely unintelligent and there is no memory or learning; nevertheless, they behave in a strangely 'purposeful' fashion, find their way out of an enclosure or into their hutch, seek out moderate lights and avoid bright ones. They are capable of a rudimentary form of self-recognition and mutual recognition and can be made to 'feed' themselves. Although anatomically they resemble very primitive creatures—Rotifera—in some respects, they are more sophisticated than lower mammals. Their mock-biological name is *Machina speculatrix*, since, unlike most machines, which are essentially passive tools, they actively investigate and explore their environment. It would seem that spontaneous exploratory activity, self-control, the solution of Buridan's dilemma, moderation, discrimination between end and means, self-recognition, and mutual recognition can appear at reflexive levels and do not require more elaborate anatomy or physiology. An inference from this proposition is that the relative passivity of the mammalian spinal cord (where reflex action has been

* Substance of a Friday Evening Discourse at the Royal Institution on March 16.

most thoroughly studied in real animals) is a specialized attribute of animals with highly developed brains, and that the elaborate form of behaviour in sub-mammals known generally as 'instinctive' is a combination of reflexive patterns which have not been subordinated to the learned modes typical of mammals and particularly of primates.

Another model has been built to show how the characters of the innate releaser mechanism can be achieved in a single mechanism, and how this form of behaviour may vary with activity and be particularly vulnerable to changes in the internal environments such as 'starvation' or 'satiety'.

Of greater relevance to the study of human mentality is the imitation of the process of learning by association or conditioned reflex formation. Analysis of this process as it actually occurs in animals suggested that, in the simplest case, it could be considered as involving a chain of seven distinct operations, known respectively as: (1) differentiation of specific stimuli; (2) extension of neutral stimuli; (3) mixing of (1) and (2); (4) summation of degrees of coincidence achieved in (3); (5) activation of storage system when degree of coincidence in (4) has exceeded chance expectation; (6) storage of the information that the coincidence has exceeded chance expectation; (7) combination of the stored information with a fresh neutral stimulus to provide a novel mode of responding to the previously neutral, now 'conditioned', stimulus.

These operations can be embodied in a working model, and such a model can be seen to 'learn' in the sense that it can discriminate between random events and those which are significantly related, and can then respond to a part of the significant association as if the whole were present. An important inference is that learning in this sense and pattern recognition are essentially the same process. A pattern may be defined as a class of relations between events which is likely to operate a learning mechanism.

The actual models (known as *Machina docilis*) of learning display several peculiarities which at first seemed to be faults but may be instructive. When set up to demonstrate a defensive rather than an appetitive conditioned reflex, it was found that the 'learned' pattern was often self-maintaining; it was not easily extinguished by lack of reinforcement. Reconsideration of animal behaviour and of human neuroses suggests that this may indeed be a property of complex behaviour based on the avoidance of pain, and that the intractability of obsessional and compulsive neuroses may be due to their liability to self-reinforcement. Again, when a neutral stimulus is given to the model in a carefully timed rhythm, the system can be induced to respond as if it had 'invented' a specific stimulus which it had never, in fact, experienced. This rudiment of originality also seemed tiresome at first; but bizarre illusions and fantasies can, in fact, be induced in some human subjects by rhythmic stimuli and it is possible that, as in the model, this effect may be due to the direct activation of a storage circuit by the cumulative action of the imposed rhythm.

The fundamental notion underlying this description of associative thinking is that mentality is based on a statistical or probabilistic analysis of experience rather than a logical or deterministic one. In fact, mentality could be defined as the rate of change of behaviour induced by statistically significant associations. This notion is not so far removed as it may seem from the real problem of brain and its function; a capacity to learn is the diagnostic character of brain, and the hypothesis that a learning brain is perpetually scanning the world of experience for statistically significant information suggests a fresh experimental approach to the problem of how animals learn. In fact, reconsideration of the protocols of conditioned reflex experiments designed to induce 'experimental neuroses' has disclosed a previously unsuspected pattern in those stimulus arrangements which were found to disturb the animals. It looks very much as though an animal—human or otherwise—in a learning situation is acting as if it were a statistical computer set to accept, as significant, odds greater than 1,000 to 1 against chance association. If the basis of learning is the computation of contingency, then most animals are considerably more sceptical than professional statisticians, who generally consider odds of 100 to 1 against chance as indicating significance.

Experiments suggested by these analogues of reflexive and associative behaviour are now in progress. Naturally, the hypotheses will be found inadequate; but there is no reason why other models should not be designed to match observation still more closely. There is even a possibility that, in the more distant future, devices that began as instructive toys may develop into powerful tools. We are already entering a phase of our culture when our arithmetic, algebra and even our material production are being delegated to mechanical extensions of our five wits. Eventually, the mental functions of conjecture and imagination may also be shared with the successors of these humble mechanical 'protozoa'.

OBITUARIES

Prof. H. F. Baker, F.R.S.

Henry Frederick Baker, who was Lowndean professor of astronomy and geometry at Cambridge from 1914 until 1936, died on March 17. His name is chiefly remembered as the founder of a vigorous and distinctive school of geometry, but his influence on the mathematical life of Britain was wider than this.

Baker was born in 1866 and was educated at the Perse School and at St. John's College, Cambridge. His progress as a student was impeccable—joint Senior Wrangler in 1887, first division of the first class in the Mathematical Tripos of 1888, and Smith's Prizeman in 1889, in which year he was elected to a fellowship at St. John's which he held until his death nearly sixty-seven years later. So at the age of twenty-three he embarked on the career of a Cambridge don which he was to follow throughout his life. He did not travel widely; but he had contacts with mathematicians in all parts of the globe, and a visit to Göttingen to study under Felix Klein had a decisive influence on his development as a mathematician. He thus began his work in Cambridge while Cayley, Stokes and Adams were still the dominant influences in Cambridge mathematics. Cayley, who shared with Klein the role of chief formative influence in Baker's mathematics, did not

die until 1894. It was very appropriate that, when a lectureship was founded in memory of Cayley, Baker was appointed the first holder, in 1903.

Baker quickly threw himself into the work of a college don, and was soon carrying a load of teaching which would make the modern don shudder. He had to teach all the subjects required for the Mathematical Tripos; but in his formal lectures he specialized in the theory of functions and geometry. His principal interest at this time was the theory of algebraic functions, and in spite of his heavy teaching duties he managed to get through a prodigious amount of reading. His first book, "Abel's Theorem and the Allied Theory" (1897), is a monumental work, and his second book, "Multiply Periodic Functions" (1907), is a thorough study of the theory associated with theta functions of two variables. But his papers cover a much wider range—the theory of functions, continuous groups, multiple integrals, projective and algebraic geometry. While a good deal of his original work of this period has been superseded by modern developments, much of permanent value remains, and I recall the pleasure which it gave Baker, only a couple of years ago, to supply reprints of a paper fifty years old which a leading group of American mathematicians was anxious to obtain.

In 1913, Sir Robert Ball, the Lowndean professor who had followed Adams, died, and early in 1914 Baker was elected his successor. The six previous holders of the chair had all been astronomers, and the University statutes of the period did not explicitly allow the Lowndean professor to specialize either in astronomy or in geometry; so Baker, with a characteristic devotion to duty, immediately offered a course on periodic orbits, not in place of, but in addition to, the lectures on the theory of functions which he had been scheduled to give before his election. He kept up his lectures on dynamical astronomy for many years, and a number of distinguished astronomers have spoken of these lectures in the highest terms. But from 1914 onwards he concentrated more and more on geometry, and for some years before he retired his lectures and writings were all on geometry. During his long retirement he continued to work on geometry, and in 1943 he published "An Introduction to Plane Geometry", followed in 1946 by a Cambridge Mathematical Tract, "A locus with 25920 linear self-transformations"; and only two months before his death he completed, in spite of failing eyesight, a commentary on some of his earlier books.

After the First World War, Baker set about building up a school of geometry, and succeeded so well that the 'Baker school' still has its distinctive character. At first the emphasis was primarily on projective geometry, along the lines of von Standt and Reye. To this period we owe the first four volumes of his "Principles of Geometry", which became the bible of his followers. This work reaches its climax in the fourth volume, which deals with the numerous special configurations and loci in four dimensions and their relations with classical configurations such as the double-six in three dimensions, with infectious enthusiasm and many characteristic touches. Later, he lectured more on the birational theory of surfaces, as developed by the Italian geometers, and out of these lectures grew the fifth and sixth volumes of his "Principles". His interest in Italian geometry, however, began much earlier, arising naturally from his work on algebraic functions, and in 1912 he made it the subject of his presidential address to the London Mathematical Society, perhaps the most influential single article he ever wrote. But what remains most vividly in the minds of all his pupils is the burning enthusiasm he brought to all his teaching, and the enthusiasm he kindled in his audiences. No one ever attended his lectures on geometry without gaining something which remained with him throughout his life. W. V. D. Hodge

Prof. Léon Bertin

On February 4, in his sixtieth year, Prof. Léon Bertin was killed in a motor-car accident on the frozen roads outside Paris. He had held the chair of herpetology and ichthyology at the Muséum National d'Histoire Naturelle since the death of Pellegrin in 1944.

Bertin graduated at the École Normale Supérieure of Paris in 1920 and was awarded a bursary to study for a doctorate. Under Prof. Bouvier he had been initiated, as he said, "au dur métier de la systématique" in the field of entomology, and he now took up the study of sticklebacks in a way that would have astonished Mr. Pickwick. Johannes Schmidt had just demonstrated the value of biometry in analysing the races of *Zoarces* and contrasting their diversity with the homogeneity of the populations of the European eel. Bertin applied like methods to sticklebacks and published on them a series of papers culminating in the classical "Recherches bionomiques, biométriques et systématiques sur les Épinoches (Gasterostéidés)" (1925), which won him his doctorate. The three-spined stickleback shows, in the amount of dermal ossification, a diversity which, expressed in the number of lateral shields, lends itself to numerical analysis. By examining ten thousand specimens from forty-five localities in France and North Africa, Bertin was able to correlate the degree of armature with age, salinity and latitude. Although later work by Heuts has shown that his conclusions were over-simplified, Bertin produced order from chaos and laid a firm foundation on which others have built. The French sticklebacks proved to have a life-span of fourteen to eighteen months. Later, Bertin studied large samples from Iceland and Greenland and demonstrated that these do not become sexually mature until their third or fourth summer, and that they thus conform to the rule of longer life-span in higher latitudes.

This work was followed by studies on bathypelagic eels and then on those enigmatic eel-like fishes, the Lyomeri. Bertin was entrusted with rare and precious material of these groups collected during the cruises of the *Dana*. As well as a number of smaller papers, he published three *Dana* Reports on them (the first in collaboration with Roule), and he had work on them in hand at the time of his death.

Throughout his career Bertin was associated with the University of Paris and the Museum. His courses at the University were much appreciated, and that on the eels was published in book form in 1942.

While still 'Sous-Directeur' at the Museum, Bertin organized and directed the indexing of the rich but neglected departmental library of offprints and journals. He appreciated the effect of environment on his staff no less than on the sticklebacks, and visitors to his laboratory in the Jardin des Plantes after the War were impressed by its pleasing decoration and efficient organization as well as by the ready assistance they received. No longer do we read in

ichthyological papers, "Type in Paris; cannot be found". Under Prof. Bertin the types were found and catalogued. Five fascicles of this catalogue have been published by the Museum, and Unesco funds were to have been made available for the rest.

Bertin developed a talent for popularization. The biggest work of this kind from his hand is "La Vie des Animaux" (1949–50). His contribution to the "Traité de Zoologie" is now in the press and due to appear shortly; so, too, is an English edition of "Les Anguilles".

Bertin served his country as a soldier in both World Wars, and received the Croix de Guerre for courage under bombardment in 1940. A man of distinguished appearance, his personality was dynamic and gay, and it is this that gives a special sadness to his sudden and tragic end. He leaves a widow and three children.

E. TREWAVAS

Prof. E. D. Merrill

ELMER DREW MERRILL was born on October 15, 1876, in a village near Auburn, Maine; there he grew up amid country sights and sounds. From the village school he passed to a high school in Auburn, walking the three miles in all weathers; and finally to the State College in Orono, which during his years became the University of Maine. He has written that his biological teacher roused his enthusiasm for field work; but the love of the wilds was already in him: late in life the Maine woods continued to attract him. He was compelled to earn as he learned, serving, for example, as a student-assistant in the botanical laboratory. Having graduated B.S. in 1898, he held a minor appointment until in the next year he was appointed an assistant agrostologist in the Department of Agriculture at Washington.

Merrill's excursions in Maine had provided him with a small collection of about a thousand dried plants; and his first entrances into print were records of Maine plants. Three years at Washington led to half a dozen short papers on grasses, along with a valuable training in method. Unexpectedly, he was offered the post of Government botanist in the Philippine Islands. He demurred as untrained for such a responsibility; but it was pressed on him and he arrived in Manila in March 1902, having visited the botanical establishments in Ceylon and Singapore on the way. His beginnings were certainly an adventure: an unfurnished room awaited him. The herbarium of Philippine plants, made by Vidal and nomenclaturally co-ordinated at Kew, had been destroyed in 1897 by an accidental fire; a second herbarium which would have thrown light on the naming in the third edition of Blanco's "Flora" had been destroyed in the fighting of 1899. Such books as there had been, if not burned, had been purloined; and he started from scratch. In twenty-two years his new herbarium grew into a splendid collection of 270,000 mounted sheets and he would have written a descriptive "Flora" had he been left with the opportunities. He had travelled in all parts of the Archipelago, had had loyal support from forest officers and others interested in plants and had made very effective use of trained Filipino collectors. His office methods were direct and purposeful; and as no flora can be studied profitably in isolation he had extended his collecting of data to surrounding lands. This collection was destroyed by the Japanese. It had held the reference material for a vast output of taxonomic papers; but the magnitude of the loss on its destruction is lessened by the existence of duplicates in many herbaria which he, thinking internationally, had distributed abundantly.

As a prelude to the projected Flora of the Archipelago, he published in 1912 a descriptive "Flora of Manila" to support teaching in the University, and to teach was immediately added to his duties. In 1919 a further portion of his time was withdrawn from botanical research, for he was required to take the post of director of the Bureau of Science. His reaction to added work was to lengthen the day; but he could and did turn the projected descriptive "Flora" into an "Enumeration of Philippine Flowering Plants", which appeared during 1923–26, the fourth and last volume holding a masterly phytogeographical review.

Merrill had married in 1907, and for the sake of the children a home was made in the United States; he spent part of his leave in 1921 with them in California, returning to Manila alone. In 1923 the University of California offered him the appointment of dean of its College of Agriculture. He accepted and served there for five years. Then he was invited to be director of the New York Botanic Garden, and he also served there for five years. In 1935 he was asked to take the post of administrator of the Collections of Harvard University (otherwise director of the Arnold Arboretum), which he held for eleven years. All three posts were difficult by reason of conflicting interests; but he was remarkably successful in all of them. One who knew him intimately wrote of his qualities—quickness of perception, unfailing patience and courtesy, great store of common sense, promptness in taking action, approachableness, and consideration for others. The University of California at Berkeley joked about his early hours used in naming collections that followed him from Manila. His reliability drew unexpectedly large donations towards his projects. In New York during the distressing slump of 1930 as many unemployed stenographers as he could employ were put at his service, and he used their labour for the innovation of incorporating descriptions and illustrations among the herbarium sheets. The Harvard University units that were under his charge were commonly spoken of as the 'orphans'. His first annual report referred to the need of somehow placing them in the 'family'; but re-organization was deferred until after his retirement. His last annual report gives a retrospect of his eleven years and shows the orphans, though still orphans, growing healthily.

In advance of his seventieth birthday Merrill was released on request from administrative duties at the end of the Arboretum's fiscal year (June 30, 1946). He remained Arnold professor of botany and continued his botanical work. The dispersal of cultivated plants had become a major interest. He had criticized in 1920 the extravagant diffusion theories of O. F. Cook, and later, when at New York, had had occasion to attack fresh unsubstantial claims of pre-Columbian transfers of useful plants between the Americas and the rest of the world. In 1950 in Washington anthropological friends asked him to sum up the case against new diffusionists, and shortly afterwards one of the diffusionists challenged him to prove his position. In the next year, being in London and at work on plant distribution, it occurred to him that, as the introduction of weeds offers evidence

parallel to the introduction of cultivated plants, he could use the old records in the British Museum for his purpose, and he began to write his last book, "The Botany of Cook's Voyages". Unfortunately he was taken ill and the work was interrupted; he recovered and resumed it, but was taken ill again. At a second resumption he completed the writing, and with the help of others the book was published in the autumn of 1954, by which time he was exceedingly ill; but he lived to February 25 of this year. He had received many honours and had obtained an international position in his own branch of botany that was unmatched. I. H. Burkill

Sir Cyril Norwood

With the death of Sir Cyril Norwood on March 13, at the age of eighty, there passed an outstanding figure in the world of education of the past fifty years. His influence was comparable to that of men like Arnold in the nineteenth century. Norwood, a brilliant classical scholar from Merchant Taylors' School, gained the highest honours at Oxford and spent several years in the Home Civil Service before entering the teaching profession at Leeds Grammar School in 1901. Five years later he became headmaster of Bristol Grammar School, and during fifteen years he transformed its standards and achievements. Then followed nine years, perhaps the zenith of his school activities, as master of Marlborough College, before his migration to the headmastership of Harrow and in 1934 to the presidency of St. John's, Oxford, his former College, from which he resigned in 1946 because of his wife's ill-health.

Throughout his whole educational career, Dr. Norwood brought what has been called the 'modern approach' to bear upon the organization concerned. Without relinquishing his firm belief both in the value of a classical training for the study of language and in the study of ancient history, he was among the first to emphasize the need for a greater emphasis on the teaching of modern languages, geography, science, and later of economics. His underlying aim seemed to be to modify where necessary an existing system of education—sometimes stereotyped or stagnant—so as to meet the needs of a changing world or society, and the present arrangement of the General Certificate of Education examinations owes much to the analysis of the Norwood Report of 1943. The vast impact of the sciences, pure and applied, during the post-war years, came a little too late for him to play an active part; but it might have been interesting indeed to see his outlook upon it.

Norwood had a strong, compelling, even if at times enigmatic personality. In appearance he might have been likened to Lord Kitchener, and the methods of the two men were at times similar. His deep religious beliefs were matched by a conviction of the essential correctness and desirability of his educational policies. This caused him at times to appear despotic and ruthless. He brought criticism upon himself from some by the widespread publicity he gave to his ideas. Yet he did not deliberately seek the publicity which followed as a result of the innate conviction of his mission and his desire for progress. The value of his work was proved by the successes of his pupils and masters alike. His reserve, possibly a shyness, made him appear unapproachable to many; but others learnt to know him as a kindly, human personality and a friend of good counsel. Of all the talks which he gave throughout his life, few could have surpassed in simple, penetrating eloquence that which he delivered in the chapel of his College on the cessation of war in 1945. For him, too, it was to be the epilogue of a life filled with interest and achievement.

Dr. Robert Pohl

Over a period of fully half a century, developments in the design of rotating electrical machines have been influenced by the work of Dr. Robert Pohl, whose death occurred on March 15. He was seventy-seven years of age.

Born at Hamm, Westphalia, Pohl received his university education at Hanover and his first industrial experience with the firm of Lahmeyer in Frankfurt. At the time at which Pohl entered the electrical industry, direct-current practice was well established and the utilization of alternating current was undergoing intensive development. The dynamo was already an efficient and relatively refined machine awaiting only the devising of means further to improve its commutation. Pohl's first contribution to the advancement of electrical knowledge, made when he was little more than a student, was towards elucidating the mode of action of the interpole or commutating pole then newly invented.

Pohl went to England in 1904 to join the staff of the Phoenix Dynamo Co. of Bradford, and he was appointed chief engineer of the Company at the age of twenty-eight. He was responsible for the production by that Company of the first machine with commutating poles to be built in Great Britain. From 1905 onwards Pohl contributed, except for the period of the First World War, to the literature of electrical machinery. His more important early papers were on direct-current machines, but by 1914 he was writing on turbo-alternators.

Six months after the outbreak of the First World War Pohl was interned. He returned to Germany in 1919, where he became director and chief engineer of the A.E.G. Turbine Works in Berlin. More than thirty papers, published for the most part in *Elektro-Technische Zeitschrift* and *Elektrotechnik und Maschinenbau* between 1919 and 1938, record the contributions which placed Pohl in the first rank of designers of large electrical machines. He made one of the early experiments in the hydrogen cooling of alternators, running a machine in town's gas in Charlottenburg. By 1938 it had become clear to Pohl that he and his family could not much longer escape Nazi persecution. Through the good offices of friends he was able to get away safely to England and was joined by his wife and son. Prof. William Cramp was instrumental in securing the appointment of Pohl to the staff of his department in the University of Birmingham.

The third phase of Pohl's career was to prove no less fruitful than the first two. He brought to his teaching a wealth of practical experience, and he had the power to transmit his ideas. The British Thomson-Houston Co. retained him as a consultant, and it was not long before contributions from his pen began again to appear in the *Journal of the Institution of Electrical Engineers*. This time, inductor alternators and the behaviour of magnetic material in machines claimed much of his attention.

At the time of his retirement from the University of Birmingham Pohl was serving as a consultant in

relation to the power supply for the synchrotron which was then under construction, and here again he made a significant contribution.

The outstanding quality of all Dr. Pohl's work is its clear physical insight. Although nearly all his papers involve some mathematical analysis, it is in the originality of his physical concepts that his genius is demonstrated.

Dr. Pohl had an exceptional endowment of fine qualities. He was a man of complete integrity and liberal philosophy. His intellectual distinction he carried lightly, for he possessed a keen and subtle sense of humour which he not infrequently turned against himself. He was musical, a great reader of literature, and he had a critical appreciation of art. Perhaps his most endearing quality was a wonderful capacity for friendship with children. No one could have a more staunch friend, and countless people stand in his debt for help freely given. Pohl was almost too acutely conscious of human suffering and it might be said of him that the sharp distress of the world sometimes pressed upon his keen intellect and sensitive mind to the point of pain. Those who knew Pohl recognized in him a quality of intellect, sympathy, and understanding which is supremely rare.

JAMES GREIG

NEWS and VIEWS

Directorship of the London School of Economics and Political Science : Sir Alexander Carr-Saunders, F.B.A.

SIR ALEXANDER CARR-SAUNDERS retires as director of the London School of Economics and Political Science at the end of the year, a post he has held since 1937 when he succeeded Sir William (now Lord) Beveridge. There have been only five directors of the School since the beginning in 1895, all of them men of great distinction and breadth of experience, and the present director takes his place as by no means the least distinguished, nor the least successful, of the five. He read zoology at Oxford, but his interests in demographic and social studies led him to accept the offer of the Charles Booth chair of social science at Liverpool in 1923. Since then his contributions to the advancement of social studies and his public services generally have been numerous. He has guided the London School of Economics through what has been perhaps its most difficult period. He found for the School a happy war-time home at Peterhouse, Cambridge, and he leaves it re-established in London, a smooth-running and harmonious institution with an international standing higher than ever before. At the same time, he has been a tireless traveller and an indefatigable worker in the cause of higher education in the Colonies. He was chairman of the two Commissions which led to the creation, first of the University of Malaya, and then of the new University College of Rhodesia and Nyasaland, Salisbury. It is hoped that he will continue to preside over the Inter-University Council for Higher Education Overseas and to give the new universities overseas the benefit of his wise and experienced counsel.

Sir Sydney Caine, K.C.M.G.

SIR SYDNEY CAINE, who succeeds Sir Alexander Carr-Saunders, is well equipped for the task; he brings to his new post an almost unique experience in administration and financial affairs. He is no stranger to the London School of Economics, since he graduated there with great distinction in 1922, and he has served for many years both on the Court of Governors of the School and on the University of London Board of Studies in Economics. Nor is he a stranger to university administration, since he has been a very successful vice-chancellor of the University of Malaya since 1952. Between 1923 and 1952 he built up a high reputation as a Civil servant, first as an inspector of taxes, then for many years in the Colonial Office, and finally in the Treasury. He has served as Financial Secretary in Hong Kong, as financial adviser to the Colonial Secretary, and as head of the Treasury Delegation in Washington. Since he went to Malaya, though giving up a career as public servant, he has not cut himself off from public affairs. He has been concerned with the problems of confederation in the West Indies, and he is at present acting as economic adviser to Mr. Marshall, the Chief Minister in the new administration in Singapore.

Directorship of the Waite Institute, Adelaide : Prof. J. A. Prescott, C.B.E., F.R.S.

PROF. J. A. PRESCOTT retired from the directorship of the Waite Agricultural Research Institute of the University of Adelaide at the end of January. He had held the Waite chair of agricultural chemistry since 1924 and the directorship of the Institute since 1938. Between 1929 and 1947 he was also chief of the Division of Soils of the Commonwealth Scientific and Industrial Research Organization. For his work in Australian pedology and his studies in agricultural climatology, Prof. Prescott has achieved an international reputation; and on his retirement the University conferred on him the title of professor emeritus.

Dr. James Melville

DR. JAMES MELVILLE, director of the Grasslands Division of the New Zealand Department of Scientific and Industrial Research since 1952, has succeeded Prof. Prescott as director of the Waite Agricultural Research Institute, Adelaide. His interests are broad, but have been concerned particularly with pasture growth and quality in relation to animal production.

New Television Transmitting Station at the Crystal Palace, London

THE first regular daily television service in the world was started from the Alexandra Palace Station of the B.B.C. on November 2, 1936, and with the exception of a break during the war period, this station has provided the service for the London area since that date. On March 28, however, this service was taken over by the new television transmitting station at the Crystal Palace, where the partially completed permanent tower is a notable landmark in south London. A technical description of the new station is contained in a paper presented by Messrs. F. C. McLean, A. N. Thomas and R. A. Rowden at a meeting of the Institution of Electrical Engineers on April 4. The station is planned to have ultimately

an effective radiated power of 500 kW., in accordance with the allocation made at the European Broadcasting Conference at Stockholm in 1952. It was decided, however, that the station should open with a power of about 200 kW., but that the building and the power plant should be planned so as to facilitate raising the output to the higher value in the future. A second paper, read at the Institution of Electrical Engineers meeting referred to above, by Messrs. V. J. Cooper and W. J. Morcom (of Marconi's Wireless Telegraph Co., Ltd.) described in detail the television transmitting equipment, which is designed to operate in two parallel chains to ensure the maximum reliability in service.

The station building is buried below the terrace on a two-acre site at the Crystal Palace, and incorporates two vision transmitters of 15 kW. and two sound transmitters of 4 kW., with provision for raising these to 50 kW. and 12 kW., respectively, when necessary. The aerial system consists of eight tiers of dipoles erected around a self-supporting tower, which is tapered to a height of 440 ft. (134 m.) above ground-level, and will later be surmounted by a parallel-sided structure for a further 250 ft. (76 m.) to carry the aerial systems for future transmissions in higher-frequency bands. For the transmission of programmes between Broadcasting House and Crystal Palace, a distance of 9 miles (14 km.), two coaxial cables of 0·975 in. (2·5 cm.) diameter have been provided, for direct transmission between the terminals without intermediate equipment. The cables and their associated terminal equipment are designed for transmission in either direction, since it is proposed to use the Crystal Palace as a pick-up point for television outside broadcasts and carry the signals by the cable to the Broadcasting House switching centre for connexion to the main television network. Full details of this cable link and of its performance are given in a third paper presented at the meeting by Dr. A. R. A. Rendall and Mr. S. H. Padel, of the B.B.C. staff.

Preliminary field-strength measurements made around the Crystal Palace site have confirmed the original theoretical expectations that the population within the service area will be 1·5–2·5 millions greater than the number hitherto served by the Alexandra Palace station. The outer coverage in Kent, Surrey and Sussex is much improved, while only the area immediately surrounding Alexandra Palace and some districts to the north of London experience a decrease in field-strength. Although these areas still receive an adequate service, a minority of viewers may need better receiving aerials.

Future of Colour Television in Britain

At a meeting of members of the International Radio Consultative Committee, held in London on April 5, Sir Ian Jacob, director-general of the British Broadcasting Corporation, discussed the problem of colour television, with particular emphasis on conditions in Great Britain and the work and future plans of the Corporation. He began by pointing out that the present television programme will soon be capable of being received by 97 per cent of the British population and that there are at present six million television receivers in the hands of the public or, in other words, that 40 per cent of the population have receivers in their homes. The Corporation is conducting a series of technical tests on the N.T.S.C. system of colour television developed by the American radio industry and adopted by the Federal Communications Commission for public use in the United States; for these tests the system has been adapted to the British 405-line television standards, and the object is to determine whether the system gives a satisfactory colour picture without being degraded to any noticeable extent as a black-and-white picture on an existing receiver. The results so far indicate the possibility of a compatible system on 405 lines, and thus it may be feasible eventually to transmit a colour programme on the Band I frequencies that are at present being used and on the Band III ones which are reserved for a future second programme. If, however, a compatible system is not possible, then the only hope for colour television in Britain is to use different transmissions on Bands IV and V frequencies, and this will involve setting up completely new transmitter networks on frequencies which, from the technical point of view, are less favourable; it is not a prospect to be relished.

Turning to the question of reception, Sir Ian pointed out that, besides the technical problems, there are economic and social factors which must inevitably weigh heavily on any decision by the Government with regard to the development of colour television. He is not convinced that a colour receiver has yet been developed, even in the United States, which is satisfactory for large-scale production. The cost of such receivers still seems to be prohibitively high, and the present economic situation is such that the Government wants to restrict home demand and to limit capital expenditure. Sir Ian doubts if all the information is yet available to arrive at any national policy for colour television; but he put in a special plea that the representative bodies of the various countries of the world should keep in close touch with one another so as to secure the greatest possible amount of international standardization.

Institute of Wood Science

In view of the widespread interest in the technical aspects of wood, it has been felt for some time that there is a need in Great Britain for a national body with the avowed object of advancing scientific knowledge of wood and allied subjects, and as a result of a number of discussions held during the past year an Institute of Wood Science has been formed, with Mr. David D. Irvin, deputy chairman of the Timber Development Association, Ltd., as chairman of the Council and honorary secretary of the Institute. The main purpose of the Institute is "to advance the scientific, technical, practical and general knowledge of persons interested in the study of wood and allied subjects", and it is proposed to interpret this in the broadest possible sense. Thus, besides the study of the anatomy and chemistry of wood, etc., the words ". . . and allied subjects" are intended to include such subjects as wood adhesives, the chemistry of preservatives, pulp, woodworking machinery and similar matters which involve wood indirectly. An immediate objective of the Institute is to start a journal, and Prof. A. R. Gemmell, of the University College of North Staffordshire, has been appointed as editor.

The Institute intends to concern itself directly with education in timber technology or wood science, and ultimately it hopes to become the examining body in at least the senior examinations in this subject. Other aims and activities include the organization of meetings, lectures and excursions, co-operation with other bodies having similar objects

and the establishment of branches in various parts of Britain. The various grades of membership of the new Institute will be as follows: fellows (who will be entitled to use the letters F.I.W.Sc. after their names); associates (A.I.W.Sc.); certificated members: ordinary members; junior members; and patrons. The conditions for associateship include the higher certificate of the Timber Development Association, Ltd., or the appropriate certificate of the Institute, or, at the discretion of the Council, a university degree in science, and also three years of experience in wood science; fellowships will be granted to associates at the discretion of the Council. The main condition for certificated membership is the third-year certificate of the Timber Development Association, Ltd. The subscription (which will include receipt of the journal) will be 3 guineas a year for fellows, associates and ordinary members; 2 guineas a year for certificated members; and 1 guinea a year for junior members. Firms, associations or corporations may become patrons by supporting the Institute financially, as also may individuals if they wish to subscribe more than the normal membership fee. Further information can be obtained from the honorary secretary of the Institute, c/o the Timber Development Association, Ltd., 21 College Hill, London, E.C.4.

Higher Technological Education in London and the Home Counties

THE seventh annual report of the London and Home Counties Regional Advisory Council for Higher Technological Education, covering the year ended August 31, 1955 (pp. 40; from the Council, London; 1956), welcomes the Minister of Education's remark to the annual conference of the Association of Education Committees that he would not allow local feelings to spoil higher technical education, and points out that the Council's limited experience so far of planning courses in particular subjects regionally has not been discouraging. In several instances, two or more authorities have jointly examined a known industrial demand and achieved a significant economy with greater efficiency. At the annual meeting of the Council, Sir Hugh Linstead criticized the Minister's proposal to upgrade some twenty or thirty colleges and doubted particularly the possibility of providing even fifteen hundred additional technologists a year from the existing colleges and the possibility of properly staffing and equipping as many as twenty or thirty colleges at the higher level; these criticisms and the subsequent discussion are summarized in the report. The Council has appointed Mr. L. C. Wooder to undertake a research project into the distribution of courses of higher technological education in the region, including an industrial survey of the region, surveys of technical education, communications in relation to the situation and 'catchment' areas of colleges and population trends, and a comparative study of those factors in relation to the distribution of courses. The Council has also recommended to local education authorities which are in membership that a college should not initiate a sessional course of higher technological education unless it has every reason to suppose the course will continue to the end of the session and that if, owing to unforeseen circumstances, the course is terminated before the end of the session, the college should arrange for students to complete the course elsewhere with a minimum of inconvenience to the student. Figures supplied by the Minister of Education for full-time degree and higher diploma students in technical colleges over the three years 1952–55 indicate a marked increase in those attending higher diploma courses in engineering, and the number working for M.Sc. or Ph.D. (internal) degrees during the period rose from 59 to 116. The numbers of students for internal degrees fell from 1,641 to 1,369 and for external degrees from 761 to 544.

Parliamentary and Scientific Committee: Report for 1955

THE annual report for 1955 of the Parliamentary and Scientific Committee (pp. 22; from the Committee, 31 Palace Street, Westminster, London, S.W.1; 1956) provides the usual convenient record of the activities of the Committee during the year, including a list of addresses given to the general committee. Particular attention is given to problems connected with higher technological education and scientific man-power. During the second reading of the Agricultural Research Bill on December 13, representations regarding the present organization of veterinary research were made on behalf of the Committee by Mr. A. J. Champion, its joint honorary secretary, and by Mr. M. Philips Price, and further consideration will be given to this subject by the Committee this year. In view of the alarm expressed by several organizations as to the effect of the higher postal rates for scientific journals and publications, a questionnaire is being sent to all scientific organizations affiliated to the Committee to permit an assessment of the general position with a view to a formal and more detailed statement. During the passage through Parliament of the Rating and Valuation (Miscellaneous Provisions) Bill, the views of the scientific bodies were brought to the notice of the Government, and because of dissatisfaction about the rating position, expressed at a meeting of the Committee on July 12, it was agreed to prepare a comprehensive report for the Government on the rating position of research associations and scientific societies.

Expenditure on Government Information Services

A WHITE Paper on "Government Information Services: Statement showing Estimated Expenditure, 1955–56" (Cmd. 9591. Pp. 4. London: H.M.S.O., 1955; 4*d*. net) gives the expenditure on home services as £2,245,100, compared with £2,333,600 in 1954–55, and on overseas services as £10,495,950, compared with £10,231,700. Of this sum, £741,150 is carried on the Central Office of Information's Vote, of which £150,250 and £156,250 are for the Air Ministry and the War Office, respectively; these two Departments account for £246,700 and £359,850 of the total, respectively. Estimated expenditure for the National Savings Committee (£277,200) and the Road Fund of the Ministry of Transport and Civil Aviation (£213,000) also exceeded £200,000. Of the Overseas Estimate, £4,755,000 is on account of the B.B.C. External Services as grant-in-aid from the Post Office, £1,757,400 as Foreign Office grant-in-aid to the British Council and £2,289,800 on behalf of the Foreign Office, including the German Section. £538,800 goes to the British Council for the Colonial Office, and a further £381,700 for the Commonwealth Relations Office, while expenditure on behalf of the Colonial Office and the Commonwealth Relations Office is estimated at a further £259,800 and £494,700, respectively.

Scottish Field Studies Association : Report for 1955

The annual report of the Scottish Field Studies Association for 1955 records the progress the Association has made under difficult conditions and indicates what could be achieved if the Association had a centre of its own. During the year the number of students who attended the Field Studies Centre at Garth showed a considerable increase over the previous year, while groups under their own staff attended from a number of schools and university departments. During this year six courses at Garth are planned as follows: May 18–21, outdoor art; August 11–18, introduction to plant ecology; August 18–25, grasses, sedges and rushes; September 7–14, mosses and liverworts; September 14–17, autumn birds; and September 21–24, higher woodlands. The difficulties at Garth, which is primarily organized as a Youth Hostel Association Centre, prevent the development of the Association's activities; and it has now been decided that, when money becomes available, the Glencoe area has considerable advantages of hill and sea, moor and crags, for botanists, geologists, zoologists and others and that a centre should be established there. Particulars about the courses may be obtained from the honorary secretary and treasurer, B. W. Ribbons, Department of Botany, The University, Glasgow.

Populations of House-Mice

Some observations with house-mice have been carried out at the University of Wisconsin by R. L. Strecker under the guidance of John T. Emlen, jun. (*Scient. Amer.*, December 1955). The investigators first wished to find out whether the mice lived in compact communities or drifted about at random among the college buildings. Trappings showed that the mice were content to live within a narrow range so long as they had plenty of food and shelter. Limiting the population's food supply revealed that, as a food shortage approached, migration from the colony increased sufficiently to 'tap off' mice as quickly as new ones were born. Reproduction apparently continued normally and the remaining population showed no unusual features with regard to sex or age composition. In a further series of experiments the food supply was drastically limited, but the mice were prevented from escaping. As starvation approached, reproduction stopped completely. These investigations on house-mice show that the determining factors in population studies can be examined individually. They should lead eventually to a clearer picture of the parts played by various influences on the abundance and scarcity of animals.

A Flowering Inhibitor in *Kalanchoe*

Recent experiments with *Kalanchoe blossfeldiana*, by W. W. Schwabe (*Ann. Bot.*, **20**, 77, 1; 1956), indicate that a flowering inhibitor may be produced by long-day exposures. He has shown that single long days intercalated between numbers of short days have a positive inhibitory effect on flower initiation and are not merely ineffective. The inhibitory effect expressed as the number of inductive cycles annulled is approximately additive, provided the long days are interspersed with short days, but not if several long days are given consecutively. On the average, one long day is capable of annulling the flower-promoting effect of about 1½–2 short days. To a first approximation, flower numbers in *Kalanchoe* increase exponentially with the number of inductive cycles given—up to at least twelve short days. The inhibitory effect of long days interspersed with short days also fits an exponential curve; that is, the inhibition is roughly proportional to the amount of previous photo-periodic induction. A light break of as little as thirty seconds duration given in the middle of a long dark period is as inhibitory as a long day. If followed by a long dark period the inhibition of an intercalated long day is almost completely neutralized; a long dark period preceding it has no such effect. These results have been interpreted as due to the interaction of a flowering inhibitor with a reaction leading to flowering. A mechanism involving competitive inhibition of an adaptively formed enzyme has been described as a possible example of the kind of reaction which could account for the results presented.

The National Museum of Wales

The forty-eighth annual report (1954–55) of the National Museum of Wales is a record of steady non-spectacular but important work. Although plans for the much-needed building extensions are still in abeyance, valuable discussions have taken place regarding the proposed new department to illustrate the special industries in Wales. The Welsh Folk Museum deals with rural industries; but the Council considers it urgent that the history of industries and their present practices should be included in the Museum. Especially is this the case in a technological age and when material and information are being lost almost week by week. As usual, the staff have taken their full share of extra-mural activities within the Principality as, for example, the keeper of geology as president of the South Wales Caving Club taking part in negotiations with the view of preserving a cave threatened by quarrying, and the keeper of botany continuing his researches on atmospheric pollens and spores.

Iron and Steel Institute : Forthcoming Meetings

The eighty-seventh annual general meeting of the Iron and Steel Institute will be held at the Royal Institution (Albemarle Street, London, W.1) and at the offices of the Institute (4 Grosvenor Gardens, London, S.W.1) during May 16–17. On the evening of May 15 a Bessemer Centenary Lecture will be given at the Royal Institution by Mr. James Mitchell, past president of the Institute, and on the morning of the next day the new president, Dr. H. H. Burton, will take office and deliver his presidential address. Following this, Prof. N. F. Mott, Cavendish professor of experimental physics in the University of Cambridge, will give the ninth Hatfield Memorial Lecture, his subject being "The Fracture of Metals".

During June 5–14 the Institute will hold a special meeting in France in association with the Chambre Syndicale de la Sidérurgie Française and the Société Française de Métallurgie. During June 5–11 the meeting will be in Paris, and the remainder of the time will be spent on three excursions to iron and steelmaking areas in eastern, central or northern France. Further information on the meetings can be obtained from the Secretary of the Institute at 4 Grosvenor Gardens, London, S.W.1.

Fifth World Power Conference, Vienna

The Fifth World Power Conference will be held in Vienna during June 17–23, the headquarters of the

Conference being at the Konzerthaus, Lothringerstrasse 20, Vienna III. The theme of the Conference is "World Energy Resources in the Light of Recent Technical and Economic Developments", and the technical programme will consist of six divisions, at which the following topics will be discussed: the present status and development of power production and utilization in individual countries; the preparation and conversion of fuels; utilization of primary sources of energy; purification of waste water and exhaust gas in the production and use of energy; international co-operation in the production and use of energy. Short excursions will be available in Austria during the Conference, and afterwards a number of extensive tours of hydroelectric stations, power stations, etc., have been arranged in Austria, Yugoslavia, Italy and southern Germany. Further information is available from the various national committees, the British one being at 201–202 Grand Buildings, Trafalgar Square, London, W.C.2. Otherwise, all inquiries should be addressed to the Oesterreichisches Nationalkomitee der Weltkraftkonferenz, Vienna I, Schwarzenbergplatz 1.

Chemical Society: Officers

Officers of the Chemical Society have been elected as follows: *President*, Prof. E. L. Hirst; *Vice-Presidents*, Sir Ian Heilbron, Sir Cyril Hinshelwood, Prof. C. K. Ingold, Dr. W. H. Mills, Sir Eric Rideal, Prof. W. Wardlaw, Prof. E. D. Hughes, Prof. E. R. H. Jones, Dr. R. P. Linstead, Prof. H. W. Melville, Prof. M. Stacey and Sir Alexander Todd; *Honorary Treasurer*, M. W. Perrin; *Honorary Secretaries*, Dr. L. E. Sutton, Prof. F. Bergel and Dr. J. Chatt; *New Members of Council*, Prof. R. M. Barrer, Prof. A. G. Evans, Prof. L. Hunter, Dr. G. W. Kenner, Prof. B. Lythgoe, Dr. A. Maccoll and L. A. K. Staveley.

University of Birmingham

The following have been appointed Research Fellows in the University of Birmingham: D. B. Holt (physical metallurgy) and Dr. G. Hübscher (pharmacology). The University has received from Ciba, Ltd., of Basle, a Ciba research scholarship for three years of £700 a year for the work and training of a graduate in the techniques of organic chemistry; in the first instance, the scholar will work on the synthesis of new halogen-containing organic compounds under the direction of Prof. M. Stacey. A grant of £900 has been made by the Electrical Research Association to the Department of Electrical Engineering of the University for the continuation of research work on electric discharges in liquids.

Announcements

Dr. J. S. D. Bacon, senior lecturer in biochemistry, University of Sheffield, has been appointed head of the new Department of Biochemistry at the Macaulay Institute for Soil Research, Aberdeen, as from September 1 next.

The forty-first annual conference of the Textile Institute will be held in Blackpool during May 22–25, the subject for discussion being "New Yarns and Fabrics". Further information can be obtained from the Institute at 10 Blackfriars Street, Manchester 3.

An international conference on "Nuclear Reactions", organized by the Nederlandse Natuurkundige Vereniging, will be held in Amsterdam during July 1–7. Among the topics discussed will be elastic and inelastic scattering, capture and photo reactions, stripping and pick-up reactions and fission. Further information can be obtained from the secretary of the conference committee, Dr. S. A. Wouthuysen, Zeeman Laboratorium, Pl. Muidergracht 4, Amsterdam (*C*).

A symposium on the methods, materials and processes involved in the uses of high temperatures in science and industry, organized jointly by the Stanford Research Institute and the University of California, Berkeley, will be held in Berkeley during June 25–27. Further information can be obtained from Dr. Nevin K. Hiester, manager of the Chemical Engineering Section, Stanford Research Institute, Menlo Park, California.

The Second World Congress on Fertility and Sterility, sponsored by the International Fertility Association, will be held in Naples during May 18–26, the scientific sessions being held at the Palazzo Mostra di Oltremare and the inaugural session at the Castel Angioino. Simultaneous translations in English, French, Spanish and Italian, with the use of head-phones, will be available. In addition to the human aspects of the subject, there will be sessions on animal fertility and sterility. Further information can be obtained from Prof. G. Tesauro, Faculty of Medicine, University, Naples.

A symposium on molecular structure and spectroscopy will be held in the Department of Physics and Astronomy of the Ohio State University during June 11–15. Both the interpretation of molecular spectroscopic results as well as methods for obtaining them will be discussed. The Joint Commission on Spectroscopy of the International Union of Pure and Applied Physics and the International Astronomical Union will meet concurrently with the symposium. Further information can be obtained from Prof. H. H. Nielsen, Department of Physics and Astronomy, Ohio State University, Columbus 10, Ohio.

The annual meeting of the Société de Chimie Physique will be held in Paris during May 29–June 1, when the subject, "Superficial Reactions of Gases on Metals", will be discussed. All the fundamental phenomena affecting the development and structure of thin films formed by gases on metal surfaces will be considered, with the exception of pure absorption and catalysis. Further information can be obtained from Prof. G. Emschwiller, École Supérieure de Physique et Chimie, 10 rue Vauquelin, Paris 5e.

The Fourth International Congress on Fruit Juices will be held in the Killesberg Park, Stuttgart, during May 28–June 2, the organizers being the Zentralverband der Sussmost- und Obstgetrankein-Industrie. The Congress is under the auspices of the International Federation of Fruit Juice Producers (Paris), and official representatives of the food and health services of twenty countries, as well as industrialists, exporters and importers, will be attending. The programme will include fifteen general reports and forty-four special reports, dealing with problems both from the point of view of medicine and hygiene and from the scientific, technical and practical angles; international questions referring to production, conditioning, sales and outlets will also be considered. Further information can be obtained from the office of the Congress at Bachstrasse 26, Bonn Rhein, Germany.

MATHEMATICAL EDUCATION IN SOUTH ASIA

An international conference on mathematical education, with special reference to countries of South Asia, was held in Bombay at the Tata Institute of Fundamental Research during February 22–28, under the presidency of Prof. K. Chandrasekharan, of the Tata Institute.

In his presidential address, Prof. Chandrasekharan suggested that difficulties in South Asia stem from an inadequate recognition of the value of creative intellectual activity as part of the drive towards prosperity, and put forward five proposals to enable the creative scientist to come into his own. First, the gifted research worker must be given a suitable working atmosphere and adequate financial support; this might be done through a system of research contracts set up by a government and administered by a national committee for mathematics. Secondly, the facilities for training students in advanced mathematics must be increased, by providing graduate schools for advanced study. Thirdly, courses of study must be integrated, and the present very rigid examination system radically modified. Fourthly, the teaching staff in colleges must be reinforced, and the teacher must be given more leisure, more encouragement, and more opportunity for keeping in touch with new ideas in mathematics. Fifthly, suitable text-books must be provided; if need be, a national text-book committee, equipped with adequate funds. must be set up to seek out competent authors and induce them to write the much-needed books. Finally, the school course must be revised and rendered more elastic, since creative mathematics cannot prosper fully unless the foundations are firmly laid in the schools.

Invited addresses were given to the conference by Prof. A. D. Alexandrov (U.S.S.R.), Prof. E. Bompiani (Italy), Prof. T. A. A. Broadbent (United Kingdom), Prof. G. Choquet (France), Prof. H. Freudenthal (The Netherlands), Prof. E. Marczewski (Poland), Prof. A. Oppenheim (Malaya), Prof. M. H. Stone (U.S.A.), Prof. Hsio-Fu Tuan (China). Some of these addresses dealt with the problems of mathematical education arising in the speaker's country, and described methods which are being used in the solution of such problems. Others dealt with the application of new methods in psychology to mathematical education, with new ideas in teaching arithmetic, and with the best way of beginning the teaching of geometry.

For detailed discussion of special questions, and particularly of the five points raised in the presidential address, members of the conference were divided into three working groups, one for the school stage, one for the bachelor's or master's degree stage, and one for the postgraduate stage. Each group discussed, in its relevant context, the aim of mathematical education, the ideal scope and content of the course, the recruitment, maintenance and training of the teacher, the mode of selection of the students at the higher levels and maintenance of such students, and the necessary facilities and equipment to be required. It was concluded that, at the schools, instruction should be closely related to the needs, the capacity and the interests of the pupil, and an integrated and simplified course, including some statistics as well as the traditional subjects, should be offered. At the universities, the degree course should meet the requirements of society in general, should train those intending to teach mathematics in schools or universities, and should begin the training of the professional mathematician. The postgraduate training should fit students for research and for the teaching of advanced mathematics; here a course of lectures in the most recent developments is essential, though no formal examination should be imposed. Examinations at the lower levels should be more flexible, no student should be asked to stake his whole career on the results of a single examination, written examinations should be supplemented by oral examinations and by an evaluation of the student's total performance; where possible, teachers should participate in the examination of their own students. The provision of text-books, scholarships, summer schools and seminars, and research contracts, was examined in detail, and specific recommendations were made.

The working groups reported interim progress to plenary sessions, from which further instructions were received. Finally, the findings of the working groups were incorporated in a set of resolutions presented to and unanimously adopted by the last plenary session of the conference. This session further resolved to set up a permanent small committee for mathematics in South Asia, under the chairmanship of Prof. Chandrasekharan; this committee would bring the resolutions of the conference to the notice of responsible educational authorities in South Asia, and press for the rapid implementation of these proposals. It is hoped to have on this committee representatives of India, Pakistan, Burma, Ceylon, Indonesia, Malaya-Singapore, and Thailand.

No member of the conference could fail to be impressed by the vast problems confronting the teachers of mathematics in South Asia, the urgent needs of the students in those countries, and the enthusiasm of their teachers. Perhaps because of the magnitude of the problems, the conference worked harmoniously, national and sectional interests seldom being allowed to intrude. But above all, the success of the conference was due to the knowledge, skill, organizing ability and driving force of the president, Prof. Chandrasekharan. He focused attention on special problems, induced strong and definite resolutions, and left no doubt in members' minds that great efforts will be made to have these proposals accepted and implemented by the appropriate authorities in the countries of South Asia.

SCIENCE AND PEOPLE

In his presidential address to the American Association for the Advancement of Science at Atlanta on December 28, 1955, Dr. Warren Weaver, of the Rockefeller Foundation, examined the influence of science on people (*Science*, **122**, No. 3183).

Science, he said, has impressively proved itself to be a powerful way of dealing with certain aspects of our experience. These are, in general, the logical and quantitative aspects, and the method works superbly for linear and stable physical problems in two or three variables. The physical universe seems to be put together in such a way that this scientific

approach is exceedingly successful in producing a good, workable, initial description. With that kind of solid start, physical science can then safely proceed to elaborate more sophisticated theories.

How far these methods will be successful in the world of living things is not yet known. The successes to date are very impressive. One feature after another that previously seemed to fall in a special 'vital' category has usefully yielded to biochemical or biophysical attack. As yet only a beginning has been made. How far the logical quantitative method will succeed here, it would be rash to forecast, although the prospects seem extremely promising.

Small beginnings at extending the scientific method into the social sciences have been made. In so far as these fields can be dealt with in terms of measurable quantities, they seem to present closely intercoupled situations that can very seldom usefully be handled with two or three variables and often require very many—for example, W. Leontief's input–output analysis of the United States economy deals with some fifty variables and regrets that it does not handle more. Science has, as yet, no really good way of coping with these multivariable but non-statistical problems, although it is possible that ultra high-speed computers will inspire new sorts of mathematical procedures that will be successful in cases where the effects are too numerous to handle easily but not numerous enough or of suitable character to permit statistical treatment. If we try to avoid the many-variable aspect of the social sciences by using highly simplified models of few variables, then these models are often too artificial and over-simplified to be useful. The statistical approach, on the other hand, has recently exhibited—for example, in the stochastic models for learning—new potentialities in the field of human behaviour.

It is not at all necessary that the particular analytical techniques of the physical sciences be forced upon biological or social problems with the arrogant assumption that they can and should make unnecessary other types of insight and experience. During the Second World War, an extremely useful collaboration was developed, known often as operations analysis, in which reasoning of a mathematical type was applied to certain aspects of very complicated situations, but with no expectation that judgment, experience, intuition, or a vague sort of general wisdom would be displaced or superseded—rather only that these would be aided by whatever partial light could be furnished by quantitative analysis.

An important characteristic of science is its incapacity to be impractical. The most far-reaching discoveries and the most widespread useful applications flow regularly out of ideas that initially seem abstract and even esoteric.

Science presents the kind of challenge that attracts to it young men and women who tend to have a rather high degree of a certain kind of intelligence. But scientists are not special creatures: they are people. The great majority of scientists have the same distribution of moral and intellectual characteristics as other educated people.

If scientists are human, so also is science itself. For example, science does not deserve the reputation it has so widely gained of being based on absolute fact, of being wholly objective, of being infinitely precise, of being unchangeably permanent, of being philosophically inescapable and unchallengeable. There seem still to be persons who think that science deals with certainty; it deals with probabilities.

The ablest scientists themselves realize the postulational and provisional character of science. Perhaps not so widely recognized or accepted is the extent to which the development of Western science has been influenced by the general nature of Græco-Judaic culture, including especially the standards, arising within that tradition, of what is interesting and important.

The previous comments concerning general characteristics of science suggest that science is a very human enterprise, coloured by general ideas, changeable as any human activity must be, various in its possible forms, and a common part of the lives of all men.

Even the impressive methods that science has developed involve only improvement of procedures of observation and analysis that the human race has always used.

These comments do not support the concept of science as some sort of super creed. This point of view does not justify the notion that science is so special as to be unique, as well as so curious as to be incomprehensible. This does not depict scientists as strange creatures who are in one sense so objective, judicial and precise as to be incredible, and in another sense so apart from life as to be selfish and sinister. This does not set up quantitative analytical Western science as the only valid way in which man may approach and interpret experience.

These descriptive comments picture science as the servant of man, not his master; and as a friendly companion of art and of moral philosophy.

The lack of general comprehension of science is dangerous both to science and to the public, these being interlocked aspects of the common danger that scientists will not be given the freedom, the understanding and the support that are necessary for vigorous and imaginative development.

TECHNICAL INFORMATION SERVICES IN EUROPE

UNDER the title "Technical Information Services in Europe", the European Productivity Agency of the Organization for European Economic Co-operation has published a report on the second meeting of technical information officers, held in Frankfurt-am-Main during May 2–6 last (from the Organization, 2 Rue André Pascal, Paris, 16e). The conference, which included delegates from twelve different countries, was intended to give participants an insight into the functioning of the technical information services which are an integral part of the German Productivity Centre at the Rationalisierungskuratorium der Deutschen Wirkschaft in Frankfurt, and the first section of the report outlines the services, activities and relations of this body. It is a private organization which has as its aim the rationalization of the entire German economy and increased productivity, and in this task representatives of science and engineering, of industry, and of trade, commerce and crafts, of trade unions and of government agencies are co-operating with it. It is organized both on a regional and on a subject basis and has a priority programme covering those fields where it is believed that an actual increase in productivity can be achieved. In referring to information services, Dr. Magnus, of the board of directors of the Rationalisierungskuratorium, emphasized the im-

portance of bringing the inquirer to formulate his question correctly. Besides describing the activities of the information service, which up to April 1955 had answered more than ten thousand questions, this section of the report gives a brief account of information and documentation in Germany, including the work of the German Society for Documentation, the Association of German Engineers, and the Association of German Mechanical Engineering Firms and the Prior Art Information Service, Treuhandstelle Reichspatantamp, Berlin, and also of the operation in Germany of the Documents Exchange Scheme of the Organization for European Economic Co-operation.

The second section of the report deals with the activities and projects of the European Productivity Agency in the field of technical information, including Dr. A. King's address on the general policy of the Agency, which emphasizes that, to be efficient, the Agency must concentrate on work that is better done on an international basis than nationally. Much of the Agency's work next year will be devoted to encouraging relations between the various national productivity centres and to services which may be of use to them all. Dr. King also emphasized the importance of forward thinking on productivity matters and of providing a forum for the discussion of particular topics which may be only germinating in the minds of men in individual countries, so that understanding can be reached which will lead to international attack on a problem and accelerated action. In this connexion he said that the Agency had appointed a working party to consider automation and particularly its human relations and economic problems and the relation of the whole subject to the future industrial pattern of European countries. The Agency has also been considering the economic switch-over which the introduction of automation will entail. Dr. King thought that in the past technical information work was too narrowly conceived and that its main task is to serve industry with the object of increasing productivity levels. He urged a closer relation between management and human relations and labour, on one hand, and the technological and technical information activities, on the other, and that at present not enough technical information of the less technological type is disseminated. Much new work is required of a research, survey and experimental nature in connexion with the social problems of technical innovation.

Suggestions made at the conference for future activities included the recommendation that the work of national technical information centres be undertaken for the general needs and within the scope of the overall productivity programme of the countries and productivity groups, and that the European Productivity Agency should intensify its relations with international vertical organizations and other international organizations in the field of technical information. The Agency was also asked to consider extending its system, in co-operation with the national technical information services, to include problems on management, human relations and similar topics. It was agreed that national technical information services should be encouraged to adopt the field officer method of providing technical information and that, while the Documents Exchange Scheme should not be regarded as a substitute for personal, organizational or multilateral contacts, which the national centres should encourage, it should include as much unpublished material as possible; in general, such centres should help each other with material which it is difficult to obtain. The conference suggested that those countries in which 'technical information days' have not yet been organized should make use of this idea, and that the European Productivity Agency and national centres should use every kind of publicity and publication to spread knowledge about technical information services.

COMMONWEALTH FUND, NEW YORK

ANNUAL REPORT FOR 1954–55

THE thirty-seventh annual report of the Commonwealth Fund, New York, covering the year ended June 30, 1955*, records that forty-one Fellows were appointed to hold fellowships in the United States during 1955–56, and another sixteen will be in residence on second-year extensions, bringing the total of Fellows elected since 1925 to 729. This figure includes 550 scholars appointed on applications through universities in Great Britain, and 139 Civil servants, of whom forty-two were from the Home Civil Service and ninety-seven from the Dominion and Colonial Services. It also includes thirty-three scholars from Western Europe in a programme of Continental fellowships which was started in 1952. Of the total appropriation of 3,469,972 dollars during the year, 1,954,071 dollars was in the field of medical education, including research in educational environment and procedures and the evaluation of educational experiments, while a further 210,000 dollars was appropriated for advanced medical fellowships, and 206,650 dollars for advanced nursing education, including twenty-one new and five extended awards as well as block grants to five institutions. Appropriations of 887,926 dollars for medical research were voted for nine projects, four of which were for studies of organism-environment interaction, two for studies of integrative processes within the organism and three for studies in basic biology. Ten other projects have continued to receive support from appropriations voted in previous years. Grants for experimental health services totalled 137,750 dollars, including a renewed grant of 118,250 dollars to the Hunterdon Medical Centre, New Jersey, to underwrite, for the next three years, two-thirds of the cost of the Centre's community mental-health programme and 19,500 dollars to the Tennessee Medical Foundation for operating costs during the next two months. The Fund's publication programme continues to provide, in conjunction with the Harvard University Press, for the publication of manuscripts and books emanating from projects supported by the Fund in the field of health.

The appropriations for medical education went to twenty-seven institutions, six appropriations being grants for new projects and ten being extensions of assistance to old ones, while fifteen institutions received assistance from previous appropriations. Four of the new projects reflect the increased collaboration between medicine and social science. A three-year grant to Yale University was for an experimental graduate training programme in the social aspects of medicine, in which the experience

* Commonwealth Fund. Thirty-seventh Annual Report for the Year ending June 30, 1955. Pp. vii+46. (New York: Commonwealth Fund, 1955.)

with health and medicine will come in the last two years of a four-year period of graduate study. At the University of North Carolina a two-year grant will permit further joint research between the Division of Health Affairs and the Institute for Research in Social Science. A two-year grant to the Bureau of Applied Social Research of Columbia University and the University of Pennsylvania School of Medicine is to extend to the study of the influence of environmental factors upon the educational process which occur in the last four years of medical studies. The University of Kansas received a two-year grant for the Department of Psychology to pursue an investigation of the doctor–patient relation in a rural community, and a two-year grant to the University of Florida is to assist in making the Health Centre, which includes the Medical School, an ntegral part of the University.

A grant to the Western Reserve University, Cleveland, was to complete the revision of the entire curriculum of the four years of the medical school, and a separate grant was made for the continuing evaluation of the students' progress. Terminal grants were made to the University of Colorado School of Medicine for the support of the General Medical Clinic at Denver General Hospital and for research in education and the cure of patients. An appropriation was made to McGill University for a two-year survey of the medical curriculum, and a new programme of instruction at the Department of Pediatrics, Harvard University, will emphasize growth from the pre-natal period to physical maturation, preventive aspects of pediatrics, and service and teaching, which include the home and community environment and effective patient–doctor relation.

HELICAL NATURE OF THE COLLAGEN FIBRIL

By Dr. R. REED, Miss M. J. WOOD and Dr. M. K. KEECH
Department of Leather Industries, Department of Medicine,
University of Leeds

THE electron microscope has provided much information regarding the structure of the collagen fibril. In the main, however, it has proved difficult to correlate such information with that obtained from other fields of investigation. X-ray diffraction studies have indicated that the polypeptide chains in collagen are likely to have a helical configuration, and recent work[1] has been concerned with deciding which particular form of helix best fits the diffraction data. We wish to report certain electron microscope findings which indicate a helical arrangement of filaments, that is, *bundles* of polypeptide chains, within the collagen fibril.

During a study of the effect of various reagents on collagen fibrils over the *p*H range 1–12·5 and at temperatures between 25° and 37° C., we have observed that the fibrils often assume a helical form (Figs. 1–8). This helical form usually occurs in the early stages of reaction; with longer reaction times this may disappear and more deep-seated changes may set in, characteristic of the reagent used. The fibril, in assuming the helical form, is transformed into a series of structures with tapering ends, to which we give the name 'helical tactoids'. These vary in length from 6000 to 12,000 A. and are 1000–2000 A. in width (Figs. 1, 2, 5, 8 and 10). They tend to become shorter as the *p*H value increases, and their angle of inclination to the fibril axis varies with the degree of swelling. The helix determined by these tactoids has no preferred direction, for both left-hand and right-hand forms are observed; Fig. 1 shows that both forms may occur at different regions in a single fibril. Subdivision of the helical tactoids into thinner structures may occur, especially under highly acid conditions, and this process does not radically affect the characteristic cross-striations, which lie at right-angles to the fibril axis (Figs. 2 and 3). With increasing subdivision of the helical tactoids, the fibril loses cohesion, becomes flattened and ultimately gives rise to a system of crossed filaments (Figs. 3, 6 and 7), in which the outlines of the cross-striations can still be seen. Depending on the conditions, the filaments vary in width over the range 200–500 A. With some reagents at *p*H 2·0, and which produce rapid swelling and disintegration, the fibrils become ribbon-like, with a raised helical centre portion (Figs. 4 and 6). Helical tactoids have also been observed[2] during the thermal shrinkage of tanned collagen fibrils (Fig. 9).

In view of these observations, we propose a fibril architecture based on two regular helical systems of filaments. These helices, determined by the filaments, are equivalent in every respect, except that one is right-hand in direction, the other left-hand. Such cross-helical systems are often observed in the electron microscope (Figs. 3, 6 and 7) and are also suggested by the presence of both helix directions within the same fibril. To account for the helical tactoids, we propose that certain filaments in the cross-helical array are more sensitive to heating and chemical reagents than are the other filaments. In other words, we suggest that helical tactoids indicate a cross-helical array of filaments, but which are not all of the same chemical composition. At the level of organization of the polypeptide chains, coiled-coil configurations based on a unit of three polypeptide chains have recently been proposed[1] by workers in the field of X-ray diffraction. As Cowan, McGavin and North[1] have pointed out, however, if one accepts such a three-chain unit, the chemical data lead directly to the concept of mixed-chain types. For one of the three chains in the unit to contain the sequence —pro—hypro—gly— to any large extent (as indicated by sequence studies[3]), from the number of residues available it must also contain the bulk of the prolyl and hydroxyprolyl residues. Thus these workers imply that the collagen fibril is built from a unit of three polypeptide chains, one of which is different in chemical composition from the other two. While agreeing that mixed polypeptide chains are likely to exist within the collagen fibril, we do not think that such a unit would account for the electron microscope observations. Indeed, we consider that the fibril architecture is better accounted for in terms of 'filaments' of differing chemical composition. Thus we suggest that various types of filaments are present, each based on different chain types, any single filament, however, containing

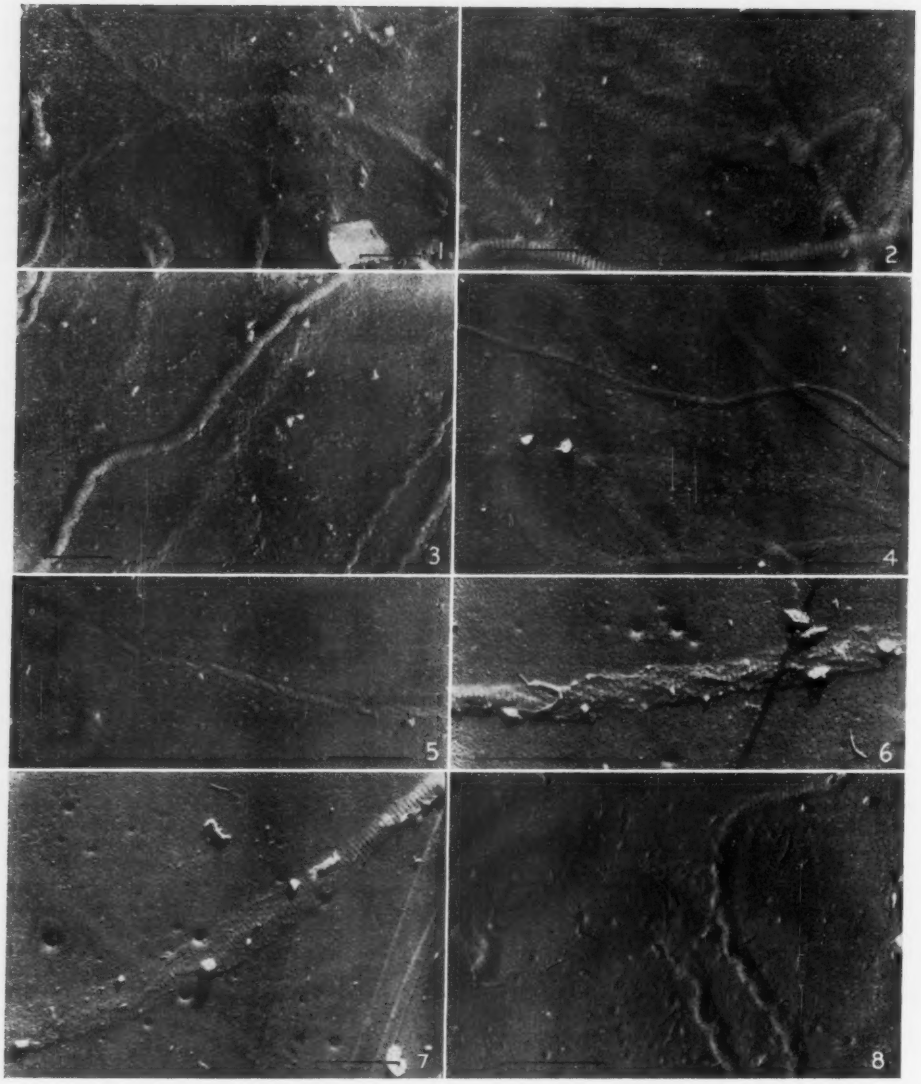

Fig. 1. Human dermal collagen fibrils after 30-min. exposure at 25° C. to an aqueous solution, *p*H 1·8, containing 1 per cent periodic acid and 1 per cent sodium chloride. Note left and right helices within the same fibril

Fig. 2. Same as Fig. 1, showing subdivision of helical tactoids

Fig. 3. Same as Fig. 1, showing system of crossed filaments in which the cross-striations can still be seen

Fig. 4. Different sample of same substrate used in Figs. 1–3 after 5-min. exposure at 37° C. to a 1 per cent solution of performic acid. Highly swollen, ribbon-like fibrils with raised, helical central portion and reduced band spacing

Fig. 5. Same substrate after 1-hr. exposure at 25° C. to a 10 per cent solution of calcium chloride at *p*H 7·0

Figs. 6 and 7. Effect of dichloracetic acid on a collagen fibril showing crossed helical system of filaments with persistence of cross-striations

Fig. 8. Same substrate as Figs. 6 and 7 after 18-min. exposure at 37° C. to a carbonate buffer solution, *p*H 10·4

chains of the same type. Thus, if the chains rich in hydroxyproline were concentrated into one filament, and the series of hydroxyproline-rich filaments were regularly distributed along the fibril, the helical tactoids could arise by such filaments becoming detached from the cross-helical array. This would mean (referring to Fig. 10) filaments rich in hydroxyproline along the lines *A–A*. To account for the observed subdivision of the tactoids, there must also be thinner but similar filaments along the lines *B–B*, for example. The details of the distribution of the filaments within the fibril, however, still need to be worked out. Thus it is not impossible that the fibril consists of two equally large strands, which spiral around each other. In turn, this cross-helical system is spirally covered, either in the left- or right-

hand direction, with filaments which contain the bulk of the chains rich in hydroxyproline. By removal of the spiral covering of filaments (rich in hydroxyproline) the fibril would assume a two-strand form, similar to that in Fig. 9.

Such filaments, rich in hydroxyproline, could account for the preferential liberation of hydroxyproline-rich fragments from disks of collagen, when alkaline buffer solutions are forced through them[4]. Further, they might also determine the stability of the fibril by being more sensitive towards heat than the other filaments, as indicated by the work of Gustavson[5], who has shown that the hydroxyproline content of various forms of collagen fibrils is an index to their thermal stability.

Since the cross-striations of the collagen fibril tend to persist in spite of radical subdivision of the helical tactoids (Figs. 2, 3, 6 and 7), the material of which they are built possibly differs in chemical composition from that removed from the fibril when the tactoids are formed. Thus to some extent the tactoids appear to be separate from the cross-striations, as though the latter acted as restraints for the filaments within the fibril and were a means of controlling their lateral cohesion[6].

The proposed model affords a basis for investigating the physical and chemical behaviour of collagen fibrils. Swelling and shrinkage could be interpreted in terms of the cross-helical systems of filaments moving with respect to each other, so that they made a larger angle with the fibril axis (see Fig. 10). This process would lead to a stretching of the characteristic cross-striations and, at the same time, bring them closer together. Such effects have been observed both in native collagen and in tanned collagen fibrils (Figs. 4, 7 and 9). Keech[7] has shown that collagenase breaks down collagen into short lengths with tapering ends (tactoids). The helical model now proposed for the fibril offers a more rational explanation for such

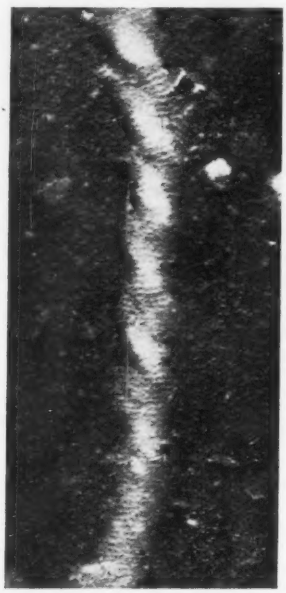

Fig. 9. Oil-tanned collagen fibril from chamois leather after 1-min. heating in water at 70° C., showing helical tactoids and contraction of the band spacing

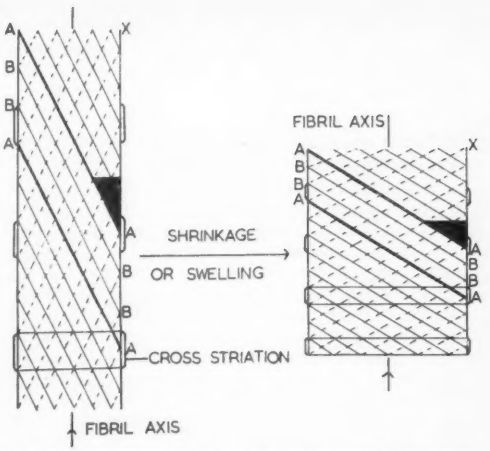

Fig. 10. Diagrammatic representation of the cross-helical system within a collagen fibril, showing helical tactoids *AAAA*. Also change of angle *AAX* and reduction in band-spacing with swelling and shrinkage,

tactoids than the flat type illustrated in Fig. 32c of her paper.

Helical structures in the collagen fibril have been observed previously by electron microscopists. Wyckoff[8] published, but did not comment upon, a cross-helical structure in the fibril following the action of dilute acetic acid. Stromberg and Swerdlow[9] consider that the cross-striations follow a helical course around the fibril. Further, they relate this helical form to an additional one, similar to that described by us. However, as we have pointed out, and indeed, as Fig. 7 in their paper illustrates, the cross-striations appear to be independent of the helical tactoid structures. These workers studied only aqueous suspensions of collagen, whereas our work has included a wide range of reagents acting both on native and on tanned collagen.

To summarize, we feel that an architecture of the collagen fibril based on a system of filaments in a regular cross-helical array best accounts for the helical structures observed in the electron microscope. Moreover, since the polypeptide chains in the fibril probably differ in chemical composition, these filaments, that is, bundles of polypeptide chains, may consist almost entirely of one type of chain, and thus they also may differ in their total chemical composition. We wish to emphasize that the helical structures based on filaments are observed at the electron microscope level of organization, and that it is still possible for the filaments to have an internal coiled-coil structure, as suggested by the X-ray diffraction studies[1]. [Dec. 19

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LETTERS TO THE EDITORS

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Oxytocin as Stimulator for the Release of Prolactin from the Anterior Pituitary

At the present time there is reason for believing that the suckling stimulus influences the mammary gland in two ways. First, there is abundant evidence (see ref. 1 for review) that suckling or other conditioned stimuli can evoke the release, from the neurohypophysis, of oxytocin, which in turn causes contraction of myoepithelial cells associated with the alveoli, resulting in ejection of stored milk from the alveolar tissue (the milk-ejection reflex). Secondly, according to the theory proposed by Selye[2], the suckling stimulus causes release, from the anterior hypophysis, of prolactin which participates in the maintenance of secretion and of the functional integrity of the mammary alveolar tissue. These facts suggested to us that the primary effect of impulses reaching the brain as a result of the application of the suckling stimulus is to activate the neurohypophysis, causing the release of oxytocin, which, by a route that need not be discussed here, reaches the anterior pituitary and stimulates the latter to release prolactin.

In order to test this hypothesis we utilized a phenomenon, first demonstrated by Selye[2], who showed that in the lactating rat the involution of mammæ, the suckling of which was prevented by the surgical removal of the nipples, was markedly retarded, provided suckling of other intact nipples in the same animal was continued. Selye's contention that this was due to the release of prolactin in response to the suckling of the intact nipples was later confirmed by Williams[3], who was able to retard mammary involution in non-suckled lactating mice, by injections of prolactin.

We have therefore studied the effects of injections of oxytocin on the course of mammary involution in lactating rats from which the litters were removed at the fourth day of lactation. Fig. 1 shows a section (*b*) from an abdominal mammary gland of a lactating rat whose litter was removed at the fourth day of lactation and which thereafter received 1·0 international unit of oxytocin intraperitoneally, three times daily, until autopsy at the thirteenth day. Comparison with the section (*a*) taken from a control rat which, instead of oxytocin, received injections of saline, shows that mammary involution was markedly retarded by the oxytocin treatment. These results are typical of most animals of the three short series (see Table 1) receiving oxytocin which we have so far studied.

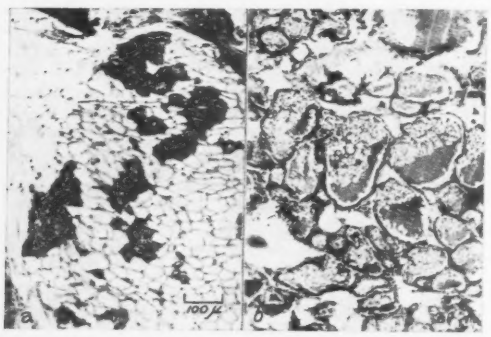

Fig. 1. Abdominal mammary glands of lactating rats from which the pups were removed at the fourth day, the mother thereafter receiving intraperitoneal injections of (*b*) 1·0 I.U. oxytocin three times daily for nine days, and (*a*) 1·0 ml. saline three times daily for nine days. Sections were cut at 7 μ, stained with hæmatoxylin-eosin and photographed at the same magnification

Table 1

Group	Dose of oxytocin	Number of animals	Mean alveolar diameter with stand. error (μ)
A	controls	5	15·5 ± 1·8
B	0·25 I.U. three times daily	4	24·6 ± 7·5
C	1·0 I.U. three times daily	4	65·7 ± 10·6
D	1·5 I.U. three times daily	4	57·9 ± 15·6*
B + *C* + *D*		12	49·4 ± 8·1

* This high standard error is due to the fact that one rat completely failed to respond.

Estimations of the mean alveolar diameter have been made measuring a hundred alveoli selected at random from each rat. The figures so obtained are summarized in Table 1. It is clear that in accord with the sections illustrated in Fig. 1, the alveoli of the treated rats were significantly larger than those of the untreated controls, particularly in the groups receiving the highest two dose-levels. This difference may be ascribed to the continuing secretion in the glands of the treated animals in contrast to the absence of secretion and subsequent general involution in the mammæ of the untreated animals. The results of these preliminary experiments indicate that the release of prolactin (and perhaps other anterior-pituitary hormones concerned in lactation) can be stimulated by treatment with oxytocin.

That neurohypophysial hormones may be concerned in the control of adenohypophysial secretion has been suggested previously by a number of workers (see Scharrer and Scharrer[4] for review; also Martini and Morpurgo[5], and Shibusawa *et al.*[6]) but principally with relation to the secretion of adrenocorticotrophic hormone.

Even if our results are fully confirmed in further experiments which are now under way, they cannot in themselves be taken as proof that the release of prolactin is evoked by oxytocin under conditions of normal suckling, but they are nevertheless consistent with this view. We consider it unlikely that the results are due to a direct effect of oxytocin on the mammary gland, because Bradley[7] in this laboratory has recently found that prolactin, alone of a number of anterior and posterior-pituitary principles tried, including oxytocin, had a localized lactogenic effect when injected intraductally into the mammæ of suitably prepared rabbits.

G. K. Benson
S. J. Folley

National Institute for Research in Dairying,
Shinfield, Reading.

Feb. 2.

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Absorption of Vitamin B_{12} from the Rat Intestine

Many animal tissues contain specific protein-like substances that combine with vitamin B_{12}. The availability of the vitamin in this bound form when given by mouth to animals depends on the origin of the binding material. Homologous bound forms are fully available, whereas a similar preparation from a different species may not be[1].

To study the importance of 'binding' in the absorption of vitamin B_{12}, it was necessary to use animals deprived of that portion of their gut where binding substances are located. The following technique was devised to allow the retention of a small amount of labelled vitamin B_{12} in a section of the small intestine for some hours without its being influenced by secretions from the stomach or duodenum. Stock-colony rats weighing approximately 200 gm. were starved overnight. The abdomen was opened under ether anæsthesia to expose the small intestine. A ligature was made near the ileo-cæcal junction and the intestine was cut above it. A similar ligature was placed near the lower end of the duodenum and the intestine cut just below this point. The cut portion of intestine was washed through with 100 ml. warm saline to remove any binding materials remaining in it and the lower end was tied off. $\frac{1}{2}$ ml. saline, containing the dose of labelled vitamin B_{12} with or without binding material, was introduced from a syringe fitted with a blunted needle into the upper end of the cut intestine, which was tied off as the needle was withdrawn. The gut was replaced and the incision closed.

The whole operation was performed as rapidly as possible with the minimum of handling in order to prevent damage to the absorbing surfaces and to retain as nearly as possible a normal blood supply to the cut segment. The rats were kept without food in a glass metabolism cage for 20 hr., and urine and fæces were collected on filter paper. At the end of this period, the rats were anæsthetized and about 5 ml. of blood withdrawn from the heart. The tied-off portion of intestine was carefully removed and dissolved by heating with 25 ml. of 4 *N* sodium hydroxide. The liver was treated similarly, and the remaining carcass and the filter paper containing urine and fæces were separately ashed. The ash was prepared for measurement of radioactivity by dissolving in the minimum volume of concentrated hydrochloric acid. All samples were counted in a liquid counter (20th Century Electronics type *M*6). Since this type of counter responds to traces of radioactivity present in animal tissues, corresponding organs from untreated rats were submitted to the same procedure and the counts subtracted from those of the experimental rats for calculation of the amount of vitamin B_{12} absorbed. Except for the carcass, these counts were not significantly above background. Typical figures for the radioactivity of the carcasses, after subtracting the background count (19 counts/min.) were: untreated rat, 16 counts/min.; rat given free labelled vitamin B_{12}, 54 counts/min.

Each rat received 60 mμgm. vitamin B_{12} labelled with cobalt-57 (2·5 mc./mgm.), either alone or with the precise amount of the test preparations required to combine with this quantity of the vitamin. The substances given with the vitamin were a saline extract of rat stomach, a crude intrinsic-factor preparation from pig pyloric mucosa ('Bendogen', G.E.A., Copenhagen) and a preparation of the binding protein isolated from 'Bendogen' by continuous electrophoresis[2]. The radioactivity found in the tissues of each rat, calculated as vitamin B_{12}, is shown in Table 1.

Table 1. Absorption from the Rat Intestine of 60 mμgm. Vitamin B_{12} Given Alone and with Preparations of Binding Proteins. Values given in mμgm. vitamin B_{12}

Binding preparation given with the vitamin B_{12}	Exp. No.	Tissues examined: Liver	Carcass	Urine and fæces	Gut and contents	Total amount of vitamin B_{12} absorbed
None	1	1·4	4·6	0·4	45·1	6·4
	2	1·6	7·7	2·4	44·4	11·7
	3	0·9	4·5	0·2	47·2	5·6
	4	1·2	3·8	0·2	42·1	5·2
	Mean	1·3	5·2	0·8	44·7	7·3
Saline extract of rat stomach	1	1·1	14·3	0·2	34·0	15·6
	2	—	—	—	—	—
	3	1·2	12·1	0·3	38·0	13·6
	4	1·6	11·0	0	35·4	12·6
	Mean	1·3	12·5	0·2	35·8	14·0
Crude intrinsic factor ('Bendogen')	1	—	—	—	—	—
	2	0·2	3·4	0·5	45·0	4·1
	3	—	—	—	—	—
	4	0·4	2·0	0·1	39·8*	2·5
	Mean	0·3	2·7	0·3	42·0	3·3
Binding protein from 'Bendogen'	1	—	—	—	—	—
	2	0·2	1·4	1·5	44·4	3·1
	3	—	—	—	—	—
	4	0	1·4	0·3	44·5	1·7
	Mean	0·1	1·4	0·9	44·5	2·4

* This figure is unaccountably low.

The content of labelled vitamin in the blood was too low to be detected by our equipment. Only small amounts reached the liver or were excreted, and the greatest proportion of the absorbed vitamin was found in the carcass. An appreciable proportion of the free vitamin was absorbed in 20 hr., but this is not surprising in view of the large dose, 0·06 μgm., that had to be used to obtain significant counts. However, addition of the saline extract of rat stomach doubled the amount of vitamin absorbed. This effect was not observed with 'Bendogen', which is known to facilitate the uptake of vitamin B_{12} in human pernicious anæmia. In fact, 'Bendogen' decreased absorption, and the binding protein prepared from it behaved similarly. Our direct demonstration of the effect of binding substances on the uptake of vitamin B_{12} is in agreement with indirect findings of other authors. Chow *et al.*[3] measured in gastrectomized rats the fæcal excretion of orally administered labelled vitamin B_{12}, and showed that intrinsic factor preparations from the pig hindered the absorption of vitamin B_{12}. Similarly, Latner[4] cites unpublished observations by Clayton, Latner and Schofield showing that human gastric juice and pig intrinsic factor inhibited absorption of vitamin B_{12} in the normal rat. Watson and Florey[5] found that rat stomach extract decreased the fæcal excretion, that is, increased the absorption of vitamin B_{12} in gastrectomized rats. Although in our own experiments vitamin B_{12} was given at more than the physiological level, the results are in agreement with those quoted above, in that rat stomach extract helped the absorption of the vitamin, whereas its absorption was hindered by a foreign binding protein.

Whatever the mechanism by which the rat stomach extract facilitated absorption of vitamin B_{12}, we showed by ultrafiltration[6] that the vitamin had entered into combination with protein. It was similarly bound to the crude and purified pig pyloric preparations, but these hindered absorption. From these experiments it is not clear whether or not com-

bination with a binding protein is the essential part of the mechanism of absorption of vitamin B_{12}. If it is, clearly the protein concerned is not the same for all animals. If the binding process is not essential, then some other factor necessary for absorption must also differ from one type of animal to another. Finally, it may well be that several factors, including perhaps the binding protein, are involved, and that any or all of these may be peculiar to a given species or group of animals.

These experiments were made possible by a generous gift of radioactive vitamin B_{12} from Dr. D. L. Mollin, of the Postgraduate Medical School of London.

E. S. Holdsworth
M. E. Coates
National Institute for Research in Dairying,
Shinfield, Berks.
Feb. 22.

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Infectivity of Ribonucleic Acid from Tobacco Mosaic Virus

In their experiments with bacteriophages, Hershey and Chase[1] have shown that only the nucleic acid component plays a part in the intracellular multiplication. There are also indications that in simple viruses containing ribonucleic acid the nucleic acid plays a dominant part in the infection. Thus, experiments with tobacco mosaic virus have shown that the protein can be changed chemically without affecting the activity and the genetic properties[2]; recently, it was even found[3] that part of the protein can be removed from tobacco mosaic virus without destroying the activity.

We have now obtained evidence that after complete removal of the protein, the ribonucleic acid itself is still infectious.

The protein was extracted from tobacco mosaic virus with phenol by a procedure elaborated by Schuster, Schramm and Zillig (to be published). After a short treatment at low temperatures, a preparation of ribonucleic acid is obtained which has a high molecular weight during the first few hours but depolymerizes in the course of time. Its physical properties will be described elsewhere.

A solution of 10 per cent tobacco mosaic virus in 0·02 *M* phosphate buffer of *p*H 7·3 is shaken for 8 min. at 5° C. with an equal amount of water-saturated phenol. The aqueous phase which contains the ribonucleic acid is separated by centrifugation, and the process of extraction with phenol is repeated at least twice for 2 min. The phenol is then extracted by ether from the aqueous phase. The whole procedure is carried out at 5° C. and takes about 50 min.; it is followed immediately by testing the infectivity.

For that purpose, five to ten plants of *Nicotiana glutinosa* with five leaves each were inoculated with a diluted solution of the ribonucleic acid, and an equal number of plants with a standard solution of tobacco mosaic virus. The number of local lesions produced by ribonucleic acid and tobacco mosaic virus are compared in Table 1. It is found that 10 μgm. of ribonucleic acid produces about the same number of lesions as does 0·2 μgm. tobacco mosaic virus. The infectivity of the ribonucleic acid preparation is thus about 2 per cent of that of the native virus.

Table 1. Comparison of the Infectivity of Ribonucleic Acid and Tobacco Mosaic Virus in 0·1 *M* Phosphate Buffer

*p*H	Ribonucleic acid μgm./ml.	lesions	Tobacco mosaic virus μgm./ml.	lesions
6·1	10	153	0·09	95
			0·8	415
7·3	10	815	0·27	1,008
7·3	1	524	0·05	795
7·5	10	998	0·27	685

The following experiments, the results of which are collected in Table 2, have been carried out to show that the infection is due to the nucleic acid rather than to contamination of the ribonucleic acid with native virus.

(*a*) In the ribonucleic acid solution protein was not detectable by chemical methods (Schuster, Schramm and Zillig, unpublished work); thus the amount must be less than 0·4 per cent of the ribonucleic acid content. By serological methods (complement fixation) it was shown that the ribonucleic acid contains less than 0·02 per cent of native tobacco mosaic virus protein.

(*b*) Treatment of both the ribonucleic acid and tobacco mosaic virus with normal rabbit serum (concentration 3×10^{-3}, applied for 10 min. at 4° C.) somewhat reduces the infectivity. There is no significant further reduction if the ribonucleic acid is treated with the same amount of tobacco mosaic virus antiserum, whereas with antiserum the infectivity of the virus itself is almost completely destroyed.

(*c*) Incubation of the stock solutions of ribonucleic acid (0·3 per cent) and tobacco mosaic virus (0·06 per cent) with 2 μgm. per ml. of ribonuclease at 4° C. for 10 min. reduces the activity of the ribonucleic acid to 0, whereas that of the virus remains almost unaffected.

(*d*) The sedimentation constant of the ribonucleic acid is 12–18 *S*, compared with 180 *S* for tobacco mosaic virus. We have centrifuged the stock solution of ribonucleic acid for 30 min. at 50,000 rev. per min. and found the supernatant liquid to be only a little less active than the original solution. If the solution of the virus is treated in the same manner, the activity of the supernatant liquid is very low.

(*e*) The ribonucleic acid is known to be unstable; and, as would be expected, its infectivity is much reduced after 48 hr. at 20° C., whereas that of the virus is much less affected.

These experiments show that protein, if present at all, is only there in very small amounts and does not resemble closely the native protein of tobacco mosaic virus. We are thus led to conclude that the infectivity is due to the nucleic acid itself.

Table 2. Comparison of Ribonucleic Acid (10 μgm./ml.) and Tobacco Mosaic Virus (0·27 μgm./ml.) in 0·1 *M* Phosphate Buffer of *p*H 7·3
(Infectivity expressed as lesions per 30 leaves)

	Ribonucleic acid	Tobacco mosaic virus
Normal	488	629
With normal serum	180	117
With antiserum	145	0
With ribonuclease	0	473
After ultracentrifugation	367	31
After 48 hr. at 20° C.	2	130

The infectivity of the ribonucleic acid preparation is about 0·1 per cent of that of the same amount of ribonucleic acid contained in native tobacco mosaic virus. Whether this relatively low value is due to a large inactive fraction of the ribonucleic acid preparation, or to low efficiency of the mechanism of infection, has still to be determined.

Studies on the combination of the ribonucleic acid with proteins are being carried out and may elucidate the connexion between our findings and the reactivation experiments of Fraenkel-Conrat and Williams[4], of Lippincott and Commoner[5], and of Hart[6].

We are much indebted to Prof. H. Friedrich-Freksa for helpful discussions, to Mr. R. Engler and Dr. H. Schuster for their co-operation, and to Miss A. Kleih for assistance.

A detailed account of this work will be published in the *Zeitschrift für Naturforschung*.

A. Gierer
G. Schramm
Max-Planck-Institut für Virusforschung,
Tübingen.
Feb. 10.

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A Possible Mode of Action of 2 : 4-Diamino-5-phenyl-thiazole Hydrochloride (Daptazole or Amiphenazole)

Some pharmacological properties and clinical uses of 2 : 4-diamino-5-phenyl-thiazole hydrochloride (daptazole or amiphenazole) have been previously considered elsewhere[1]. It often appears to exert a mild respiratory stimulant effect in both unnarcotized and narcotized patients and animals. It has been used clinically as a buffer to depressed respiration in such conditions as pneumonia, asphyxia neonatorum and in the relief of respiratory depression following anæsthesia. It has further been employed in the treatment of barbiturate intoxication (usually in combination with ββ-methyl ethyl glutarimide (*NP*13, megimide or bemegride)) and opiate overdosage, and has been administered in combination with large doses of morphine in the relief of severe and prolonged pain. When used in this latter manner, it has appeared to minimize the onset of tolerance or addiction to morphine. It is effective both orally and parenterally, and has a high therapeutic index (greater than 10). Therapeutic doses (5–50 mgm.) are almost completely devoid of side effects, and large doses (more than 200 mgm.) have been safely tolerated by unnarcotized volunteers. In small doses (20–40 mgm.) it often appears to improve the mental outlook of depressed patients.

The fact that daptazole has such widespread activity and that such large doses have been safely tolerated has suggested that this substance may fit into some fundamental physiological process.

As the structures of daptazole and the thiazole moiety of thiamine (4-methyl-5-hydroxy-ethyl-thiazole) show some similarity and, further, as thiamine appears to be the only substance occurring naturally in the body which contains the thiazole nucleus, experiments were performed in which rats (40–50 gm.) on a thiamine-free diet were given daily intraperitoneal injections of daptazole and the pyrimidine moiety of thiamine (2-methyl-4-amino-5-brom-methyl-pyrimidine dihydrobromide) to see if the combination of these two drugs would produce a substance capable of entering into thiamine metabolism[2].

Table 1
All rats on a thiamine-free diet. 10 animals in each group

Group	Drugs administered (mgm./kgm. intraperitoneally)			Period of adaptation (days)	Onset of thiamine-deficiency symptoms	Reversal by vitamin B_1
	Daptazole	Pyr. B_1*	Frequency			
Control	—	—	—	—	2–3 weeks	+
1	10	2·5	three times daily	7–10	None for 9 weeks	−
2	50	12·5	daily	—	10 days to 2 weeks	+
3	50	—	daily	—	4–5 weeks	+
4	—	12·5	daily	—	3–4 weeks	+

* Pyr. B_1 = 2-methyl-4-amino-5-brom-methyl-pyrimidine dihydrobromide.

Preliminary results (Table 1) indicate that rats, maintained on low doses of these drugs (10 mgm./kgm. daptazole hydrochloride; 2·5 mgm./kgm. 2-methyl-4-amino-5-brom-methyl-pyrimidine dihydrobromide given intraperitoneally three times daily), after a period of adaptation (seven to ten days), showed no signs or symptoms of thiamine avitaminosis nine weeks after the commencement of the treatment, whereas their controls were clearly deficient in thiamine in three weeks and had all died in five weeks.

The results also indicate that the symptoms of thiamine deficiency developed in rats maintained on a thiamine-free diet could be reversed by similar administration of these doses of daptazole and the pyrimidine moiety of thiamine. However, the daily administration of larger doses of daptazole (50 mgm./kgm.) and the pyrimidine moiety of thiamine (12·5 mgm./kgm.) to such rats appeared to bring about a more rapid induction of thiamine avitaminosis which could be reversed by the administration of thiamine. This more rapid onset of thiamine avitaminosis was not produced when either drug was given alone in these larger doses, and indeed the condition of these animals seemed better than that of their control groups. These observations suggest that daptazole may enter into the pathway of processes involving thiamine. This may be one of its modes of action, and could serve to afford some rationale for its wide sphere of clinical and pharmacological actions in apparently unrelated and diverse processes which may be dependent on thiamine.

This hypothesis is now being investigated and a full account will be published elsewhere.

A. Shulman
Department of Physiology,
University of Melbourne.
Nov. 28.

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The Leydig-cell Homologue in Certain Teleost Fishes

The male sex gland of the Craniata is, like other endocrine organs, extremely ancient in origin. It occurs in the Agnatha (for example, *Petromyzon*) and throughout the gnathostome series with relatively little recorded variation except in the Urodela. With the above exception, and another about to be described, the interstitial gland is characteristically composed of aggregations of modified connective tissue cells which occupy interstices between the seminiferous tubules of the testis. These secretory Leydig cells have a generally similar appearance, and exhibit certain common histochemical properties, in both jawless fishes and, for example, man. The interstitial aggregation of Leydig cells may constitute either a permanent secretory unit (as in most mammals) or may be renewed at the end of each breeding rhythm as in seasonal birds[1].

In the latter case, there is an annual development of large lipoidal cholesterol-positive Leydig cells from minute interstitial connective tissue cells. Unless appropriate histological methods are employed, it is impossible to distinguish connective tissue cells from immature Leydig cells. This is generally responsible for the not-infrequent claim in the literature of breeding seasons that interstitial cells were absent at a stated period of the sexual cycle of some particular bird.

In studies of fishes also, Leydig cells have often been said to be absent, or, on the other hand, have not been mentioned at all. The reason for this may sometimes lie in the fact that two strikingly distinct endocrine arrangements occur in the testes of fishes. The first (Fig. 1) is the typical vertebrate interstitial gland (Leydig cell) pattern and is found in common teleosts such as the three-spined stickleback (*Gasterosteus aculeatus*)[2], *Tilapia* spp., and the sprat (*Clupea sprattus*). This arrangement occurs also in the choanate *Latimeria* and in the widely unrelated selachians *Scyliorhinus* and *Chimaera* (unpublished work). The second (Fig. 2) and less-obvious type, arising not in the interstices but in the lobule walls, we now show to occur in the pike (*Esox lucius*), char (*Salvelinus willughbii*), and *Labeo* (sp. ?). Judged by published illustrations[3], it probably occurs in the salmon (*Salmo salar*) as well.

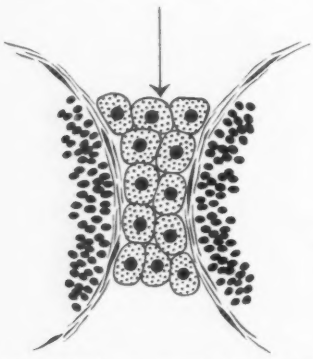

Fig. 1. Typical vertebrate arrangement of endocrine interstitial Leydig cells

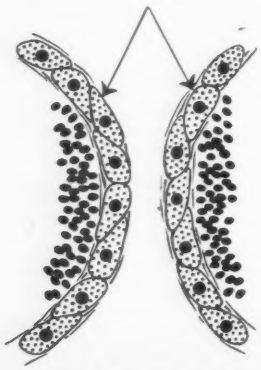

Fig. 2. The Leydig cell homologue in the lobule walls of certain teleost fishes

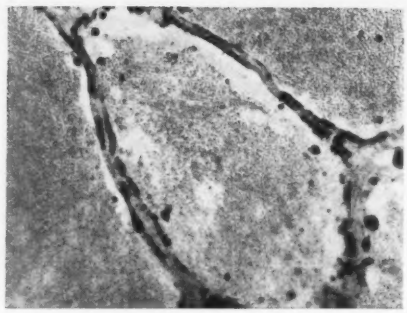

Fig. 3. Lobule boundary cells in the pike (*Esox lucius*) in March. (Formal–calcium fixation, sudan-black colouring at 10μ. × 300)

As is well known, the lobule or crypt wall in the teleost testis is, like the walls of seminiferous tubules in tetrapods, composed essentially of fibroblasts. In both pike and char these, in the absence of a secretory interstitium, become seasonally modified into lipoidal, cholesterol-positive gland-cells similar to the interstitial cells of tetrapods. We provisionally name these 'lobule boundary-cells' (Fig. 2).

The annual boundary-cell cycle is essentially similar to that of the interstitial cycle in seasonal birds. After spermatozoa are shed, the lobule contents metamorphose and the resultant sudanophil material becomes cholesterol-positive. The spent lobules are now bounded by unmodified fibroblasts. These grow, and become lipoidal and cholesterol-positive at about the same time that the sudanophil material within the lobules disappears. It is almost certain that the lobule boundary-cells have the same endocrine function as interstitial Leydig cells. They finally expend their cholesterol at the pre-spawning period in April, after which the cycle begins anew. Most histological techniques permit the loss of vital cytoplasmic lipids from boundary-cells and render them difficult to distinguish from ordinary fibroblasts; but the use of sudan dyes demonstrates their presence with unmistakable clarity (Fig. 3).

However distinct at first sight, the two types of endocrine cells are morphogenetically very similar. In most vertebrates, gonadotrophic influences operate on intertubular connective tissue and produce sexual function. In the few exceptional fishes mentioned above, the influences are on peri-lobular connective tissue, apparently with a similar result. In addition to the typical vertebrate interstitial Leydig cells in the anuran *Rana temporaria*, and in the reptile *Vipera berus*, a few tubule-wall fibroblasts may be modified in much the same way as occurs in pike and char.

In some fishes, however, the phenomenon is constant. The only interlobular elements seen by us have been blood-vessels, lymph spaces and their contents, and during the first few weeks after spawning, what appear to be primary germ cells.

It will be interesting to discover whether the distribution of interstitial Leydig cells on one hand, and the boundary-cells on the other, falls into line with current teleost taxonomy. Both char (family Salmonidae), which has lobule boundary-cells, and the sprat (family Clupeidae), which has Leydig cells, belong to the same order (Isospondyli) as at present constituted.

A more extensive account of the sexual cycle of the pike and further information on the distribution of lobule boundary-cells will appear elsewhere. We are grateful to Prof. H. Brattstrom (Bergen), Messrs. R. S. A. Beauchamp and Humphry Greenwood (Uganda), Prof. J. Millot (Madagascar), and particularly to Mr. G. J. Thompson (Windermere) for helping us to obtain study material.

A. J. Marshall
B. Lofts

Department of Zoology
and Comparative Anatomy,
St. Bartholomew's Medical College,
University of London.
Dec. 21.

[1] Marshall, A. J., *Quart. J. Micro. Soc.*, **90**, 265 (1949).
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Proposed Terminology for Wool Follicles in Sheep

The terminology proposed by Wildman and Carter[1] for hair follicle types in Mammalia has been widely used in studies on sheep, although it is in some respects unsuitable for certain other species[2,3]. However, recent workers[4–6] on the histology of sheep skin have independently extended this terminology, but not always consistently, so that confusion has arisen. To overcome this a unified system of terms and symbols for wool follicles in sheep is here proposed. Based on that of Wildman and Carter, with the major division into primary and secondary follicle types, it provides for a recent contribution to the study of the development of the wool follicle, namely, the distinction between original secondary follicles which arise directly from the epidermis, and derived secondary follicles which arise from them by branching[7,8].

The terms and symbols used in the classification of wool follicles into types are set out in Fig. 1 and defined below.

P is primary follicle, and *S* is secondary follicle as defined by Wildman and Carter[1], and Carter[9].

PC is central *P*, and *PL* is lateral *P* of a trio group as defined by Carter[9] (= P_C and P_L respectively of Fraser[5]).

PCX is member of first-formed *PC*, *PCY* is member of later-formed *PC*, *PLx* is *PL* associated with *PCX*, and *PLy* is *PL* associated with *PCY*. (The symbols *X*, *Y*, *x* and *y* are used in the same sense as by Wildman and Carter[1], and Carter[9].)

SO is original *S*, and *SD* is derived *S* as defined by Hardy and Lyne[7,8].

SOU is unbranching *SO*, and *SOB* is branching *SO* as defined by Hardy and Lyne[8].

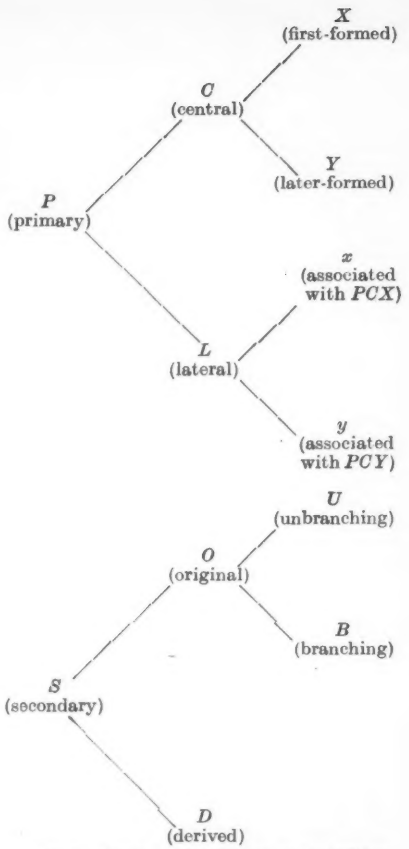

Fig. 1. Key to the classification of wool follicles

Within each follicle type three states of follicle development or activity are distinguished.

i is an incompletely developed follicle at any stage prior to the formation of a keratinized fibre, that is, at any stage from *F1* to *F5*, as defined by Hardy and Lyne[7,8]. (Carter and Hardy[10] used the symbol *p* for primary follicles in this state, and *s* for secondary follicles. Fraser and Hamada[6] used S_U for secondary follicles. Burns[4] referred to two groups of stages of incompletely developed follicles as 'plugs' and 'news'.)

f is follicle containing a fibre, that is, stage *F6* as defined by Hardy and Lyne[7,8] or any later stage up to and including that in which a fibre has ceased growing but remains in the follicle. (Carter and Hardy[10] used *P* and *S* respectively for primary and secondary follicles in this state. Fraser and Hamada[6] used S_F for secondary follicles.)

The symbols for the state of follicles should follow those for follicle types. Different combinations of symbols may be used for different purposes. Thus, while it is frequently necessary only to distinguish *P* from *S*, sometimes *PC* must be distinguished from *PL*[5,6], and in the early stages of follicle development *PCX* needs to be distinguished from *PCY*[8,10]. In any study of follicle development in early postnatal life, *Si* and *Sf* must be separated[11,12].

For quantitative work, such symbols have frequently been used for representing numbers of follicles. With the above symbols, any ratio of num-

bers of follicle types may conveniently be expressed. Thus S/P (or more strictly nS/nP) is the ratio of secondary to primary follicles, while Sf/Pf (nSf/nPf) is the ratio of secondary follicles containing fibres to primary follicles containing fibres.

In the nomenclature described above, terms and symbols which have been found useful for different purposes are combined in a single system in which there are no overlapping categories. Expansion within the system is possible if required. All the symbols except the previously defined X, Y, x and y are mnemonic, and for ease of type-setting, superscript and subscript letters have been avoided.

We would like to thank the following members of the Commonwealth Scientific and Industrial Research Organization for helpful discussions on these proposals: Mr. P. G. Schinckel, Dr. B. F. Short and Dr. K. A. Ferguson, of the Sheep Biology Laboratory, Prospect, Mr. R. H. Hayman, of the F. D. McMaster Field Station, Badgery's Creek, Miss A. G. Culey, of the McMaster Laboratory, and Dr. A. S. Fraser, of the Section of Animal Genetics, University of Sydney.

Margaret H. Hardy
A. G. Lyne
Division of Animal Health and Production,
Commonwealth Scientific and
Industrial Research Organization,
McMaster Animal Health Laboratory,
Sydney.
Oct. 6.

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Ciliary Feeding Mechanisms of Brachiopods

At the suggestion of the late Prof. J. H. Orton, I undertook a comparative study of the ciliary feeding mechanisms of brachiopods, after Richards[1] had reported a new method of ciliary feeding in *Neothyris*, which suggested that the main food and respiratory currents were produced by different methods in different brachiopods. Owing to the difficulty of obtaining diverse living material, it may be some time before the work can be completed and published; a mechanism has been discovered, however, which probably accounts for the differences in the descriptions by Orton[2] and Richards[1] of feeding in *Crania* and *Neothyris* respectively.

In Orton's account of the ciliary feeding mechanism of the inarticulate *Crania*, with spirolophus lophophore, it was shown that the lateral cilia beating across the length of the filaments created the main water current passing through the mantle cavity, the inhalant apertures being lateral and paired and the exhalant anterior and single. The frontal cilia passed food particles to the bases of the filaments and so into the food grooves leading to the mouth.

Richards, in her work on the articulates *Neothyris* and *Terebratella*, with plectolophus lophophores, although agreeing with Orton in the position of the inhalant and exhalant apertures, found that both lateral and frontal cilia beat toward the tips of the filaments, and that the inhalant current entered the lophophoral spaces of the lateral arms against the beat of these cilia. To account for this she was obliged to formulate the hypothesis that the inhalant current was produced by cilia lining the exhalant chamber and the spiral arm. She considered that their action caused a volume of water to be discharged through the anterior exhalant opening, and that to replace this, water was drawn into the inhalant chamber through the lateral inhalant openings. From the spiral arm water was discharged through the inter-filamentary spaces into the exhalant chamber.

Of the articulates, I have so far studied the terebratuloids, *Terebratulina retusa* and *Gryphus vitreus*, and the terebratelloid, *Macandrevia cranium*; of the inarticulates, only *Crania*. In all these, the lateral cilia, beating across the length of the filaments and from the inside to the outside of the lophophoral spaces, create the main water current, which in the adults, whether with plectolophus or spirolophus lophophores, enters laterally and leaves the shell anteriorly. In young stages (*Terebratulina retusa* seen so far) with simple circular lophophore (trocholophus) and with slight anterior indentation (early schizolophus), the inhalant current is single and median, setting into the bell-shaped lophophore, while the exhalant current escapes between the filaments all around, but leaves the shell chiefly laterally and ventrally, for the lophophore lies nearer the brachial than the pedicle valve. As the anterior indentation increases with age, two lateral arms being formed, the median inhalant current becomes divided into two.

The frontal currents in all the species examined are capable of reversal. Small particles are conveyed by the frontal cilia toward the bases of the filaments and eventually reach the mouth; large particles and collections of particles are conveyed to the tips of the filaments and are finally rejected from the shell. In a thick culture of *Chlorella* or other small organisms, the frontal cilia beat toward the tips of the filaments. This reversal of the frontal currents of the filaments appears to be due to reversal of the ciliary beat and not to adjacent tracts of cilia beating in opposite directions as in certain bivalves[3]. Orton[2] observed only the feeding reaction of the frontal cilia of *Crania*, while Richards[1] evidently saw only the rejection reaction of these cilia in *Neothyris* and *Terebratella*. *Neothyris* and *Terebratella* are sufficiently close allies of *Macandrevia* to make it very probable that reversal of the frontal cilia occurs in them as in *Macandrevia*. It is understandable that Orton and Richards failed to see the full behaviour of the frontal cilia, for reversal is not a consistent reaction in the opened animal and on small pieces of lophophore.

Change in direction of beat of the lateral cilia has not been observed, and it is difficult to account for Richards's statement of the direction of their beat in *Neothyris*; but the following observations may have some bearing on this. The lateral cilia sometimes have the appearance of beating somewhat obliquely, as in the ectoproct Polyzoa[4]. Also, in an opened animal, on portions of lophophore and detached filaments, these cilia are frequently more or less inactive and masked by the continuous beat of the long frontal cilia; there is little difference in length of lateral and frontal cilia in brachiopods.

In *Terebratulina retusa*, *Gryphus vitreus* and *Macandrevia cranium*, abfrontal cilia are present on the filaments and these beat continuously toward their tips.

From work now in progress, it would seem that Orton[2] was justified in his general inference from a detailed knowledge of *Crania*, and a limited knowledge of *Gryphus vitreus* (= *Terebratula vitrea*) and *Argiope*, that "the main current through the mantle cavity in brachiopods is produced chiefly by the lateral cilia on the gill filaments". It would also seem probable that reversal of the frontal currents on the filaments will be found in brachiopods generally.

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D. Atkins

The Laboratory,
Citadel Hill,
Plymouth.
Dec. 5.

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Reversal of Mating Preference by Crossing Strains of *Drosophila melanogaster*

Sexual selection may be an important component of the selection pressures determining changes of gene frequency in Mendelian populations, and a number of studies of *Drosophila* have been made with the object of assessing degree of competition for mates (see, for example, refs. 1 and 2) and have led to the conclusion that, while male vigour is an important factor, discrimination and preference between genotypes do occur and seem to be largely female attributes. In an attempt to assess the importance of mating preference as a factor affecting changes of gene frequency in some experimental populations described elsewhere[3], we have come across a phenomenon which, as far as we can discover, has not been reported before.

We wished to test the preference of w/w, w^a/w^a and w/w^a females for w^a or w males in two separate environments (one constant 25° C., the other 25° during the day and 15° during the night). The flies were obtained from stock cultures, the w/w^a females by crossing. Each female to be tested was placed in a food tube with one male of each kind for two days, and her offspring were grown and classified according to genotype of father. Failures were ignored and double matings were scored $\frac{1}{2}$. Three replicate tests gave the combined results shown in Table 1.

Over all the experiments, the two types of male have equal success ($\chi^2_{(1)} = 0{\cdot}3810$, p, 0·7–0·5); but there is significant heterogeneity within the data ($\chi^2_{(6)} = 18{\cdot}843$, $p < 0{\cdot}01$). All this heterogeneity is associated with the degree of freedom for difference between the w/w^a females and the two homozygous female types ($\chi^2_{(1)} = 13{\cdot}660$, $p < 0{\cdot}001$; residual $\chi^2_{(5)} = 5{\cdot}183$, $p \simeq 0{\cdot}3$), and the difference is in the direction that w/w^a females prefer w males, whereas both w^a/w^a and w/w females prefer w^a males. The respective degrees of preference are about equal: 0·7 of the w/w^a matings were with w, 0·6 of the w^a/w^a matings were with w^a and 0·7 of the w/w matings were with w^a.

Table 1

Environment:	25° C.			15–25° C.			Total		
Successful male:	w	w^a	Total	w	w^a	Total	w	w^a	Total
Type of female									
w/w	7·0	19·0	26·0	10·0	17·0	27·0	17·0	36·0	53·0
w^a/w^a	14·5	14·5	29·0	9·0	19·0	28·0	23·5	33·5	57·0
Total	21·5	33·5	55·0	19·0	36·0	55·0	40·5	69·5	110·0
w/w^a	18·0	10·0	28·0	21·5	8·5	30·0	39·5	18·5	58·0
Total	39·5	43·5	83·0	40·5	44·5	85·0	80·0	88·0	168·0

There is thus a remarkable difference between the mating preferences of the two types of stock female and the females produced by crossing these stocks. We cannot, of course, associate it with the marker locus, for it may be associated with genes or gene complexes anywhere in the chromosome complement. However, the observation that mating preference may be reversed by hybridization, even though the types hybridized have similar preferences, is striking. If such reversal of preference were associated with a single locus or small block of chromatin it could, in certain circumstances, be responsible for a stable polymorphism.

G. Tebb*
J. M. Thoday

Department of Genetics,
University of Sheffield.
Dec. 7.

* Now on the staff of the Poultry Research Centre of the Agricultural Research Council, Edinburgh 9.

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A Simple Potometer for measuring Rate of Water Uptake by Small Seeds

The usual method of measuring rate of water uptake by seeds is to weigh samples after different periods of imbibition. This method is not free from errors as the seeds have to be freed from adherent water before weighing, which cannot be done accurately, and, during handling and weighing, loss of water always occurs by evaporation. Furthermore, different lots of seeds have to be used for the various measurements, which is cumbersome and a disadvantage in cases where only small amounts of seeds are available.

Kruyt[1] measured water uptake by enclosing the seeds in a water-filled bottle, through the stoppered mouth of which protruded a capillary tube. By watching the fall of the water column in this capillary, water uptake was measured. In this method the seeds are totally submerged, and no attention is given to volume changes of the seeds due to swelling.

In order to determine germination-rate or metabolic changes in small and quickly germinating seeds, the seeds are usually not submerged, but are placed on wet filter paper. When water uptake has to be correlated with findings obtained by this method, the seeds ought not to be submerged, as this treatment changes their germination behaviour. The potometer described here allows water uptake to be measured in a single lot of seeds imbibing on wet filter paper during a prolonged period of time without weighing.

The edge of a Petri dish is ground and a hole blown in the middle of the bottom. A capillary tube about 65–70 cm. long is sealed to the hole and bent

Fig. 1. Diagram of potometer for measuring rate of water uptake in small germinating seeds (not drawn to scale)

as shown in Fig. 1. A ground-glass plate with a small opening in the middle, and a cover-glass or a glass slide to cover up the opening are used to close the potometer.

Before use the capillary is filled completely with water from a pipette through the Petri dish, and the free end of the capillary inserted into a beaker filled with water. A fitting filter paper is quickly inserted into the Petri dish and will absorb water from the capillary. By lifting the free end of the capillary from the beaker, an air-bubble can be introduced into the capillary, which is then lowered again. The potometer is then left open until the bubble has risen to the horizontal part of the capillary. Now the potometer is made air-tight with the cover using any sealing agent and left until the bubble has come to a standstill, indicating that the air inside the Petri dish has been saturated with water vapour. The cover is removed, a measured amount of seeds speedily spread on the filter paper and the cover instantly replaced. When a cover without an opening is used, the air pressure in the Petri dish might be increased by the closing procedure, which will result in a backward move of the air bubble, but when an opening is made in the plate, it can be quickly put in place. The opening has to be immediately closed by sliding the cover-glass smeared with 'Vaseline' sideways over it. Rate of water uptake is determined by reading the movement of the air bubble against a millimetre-scale behind the capillary.

It is advisable to have the potometer in a fixed position in a constant-temperature room and do the handling with the help of forceps and not by hand, in order to avoid temperature changes.

In our laboratory water uptake in photo-sensitive lettuce seeds has been determined by this potometer. The results will be published elsewhere.

Shimon Klein

Department of Botany,
The Hebrew University,
Jerusalem.
Oct. 25.

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A Slide-trap Method for the Isolation of Soil Fungi

The slide-trap method of isolating actively growing soil fungi, described by C. J. La Touche[1], was used in an investigation of the fungus flora of a podsolized *Calluna*-heathland soil. The method was found to be highly selective of rapidly growing species and indeed, with very few exceptions, only permitted the isolation of *Trichoderma viride* from the surface soils. A modified slide-trap was designed which greatly reduced this selectivity and permitted the isolation of a wide range of species.

The modified slide-trap consisted of a shallow chamber (Fig. 1, *Y*) covered by a glass microscope slide (Fig. 1, *X*). A 'Perspex' strip (3 in. × 1 in. × $\frac{1}{16}$ in.) formed the base of the chamber, narrow lengths ($\frac{1}{8}$ in. × $\frac{1}{16}$ in.) of the same material formed the four walls and the chamber was divided into two unequal parts by a crosspiece. Chloroform was used for joining the 'Perspex' surfaces.

The chamber was stored in alcohol and sterilized by flaming when required. Melted agar was introduced into the larger section of the chamber by means of a sterilized pipette, where it spread evenly to form a thin layer (Fig. 1, *Z*). The chamber was then covered by a sterilized glass slide, which was firmly fixed in position by two wire paper clips when the agar had solidified. All manipulations were carried out under a sterile hood in an inoculating room.

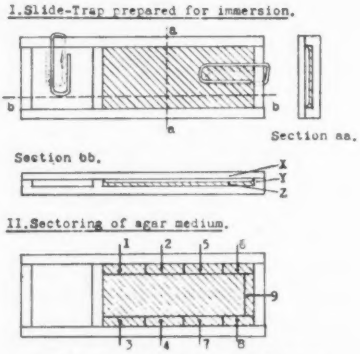

Fig. 1. Modified La Touche slide-trap

Slide-traps were immersed vertically into the soil to such a depth that the larger portion of the chamber was completely buried. The slot-shaped hole to receive the slide-trap was conveniently prepared with a square-ended chisel blade. Traps were buried in groups and were protected from rain by an inverted U-shaped piece of zinc sheeting.

After a suitable period of incubation in the soil, during which fungal hyphæ penetrated between the glass and 'Perspex' surfaces and colonized the agar medium, the slide-traps were returned to the laboratory. In routine isolation work the slide-traps were opened and portions from the edges of the agar medium were removed and plated. Usually nine small sectors of agar were removed, four from the upper part of the isolation chamber (Fig. 1, II, 1–4) and five from the lower part. These two groups of agar strips were plated separately, thus enabling a rough distinction to be made between those mycelia which penetrated the traps from the upper and lower levels of the soil sampled. Generally, two, three or four species were isolated from each slide-trap.

These modified slide-traps were economical of time and materials and were simple to use; the results obtained by their use were in close agreement with those obtained by the immersion tube method[2] and will be discussed in greater detail elsewhere.

Geoffrey W. F. Sewell*

Department of Botany,
Royal Holloway College
(University of London),
Englefield Green,
Surrey.

* Present address: Pathology Section, East Malling Research Station, Nr. Maidstone, Kent.

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Heat Treatment and Tissue Culture as a means of freeing Potatoes from Virus Y

A NUMBER of workers have shown an effect of high temperatures on plant viruses. By heat treatment, potato tubers have been freed from leafroll[1] and witches'-broom[2]; but as yet there has been no reported success with heat treatment as a means of freeing potatoes from virus Y.

The most important potato variety grown in New Zealand, Aucklander Short Top, has been shown to be 100 per cent infected with potato viruses X and Y [3]. Therefore, efforts have been directed towards eliminating virus from selected tubers, which would then become the foundation for improved seed stocks.

Table 1

Treatment	Material	Apices detached	No. surviving	No. free from virus Y
38° C.; 28 days	3 tubers	16	6	0
38° C.; 21 ,,	1 ,,	14	2	0
38° C.; 15 ,,	2 ,,	10	0	0
38° C.; 7 ,,	2 ,,	12	7	4
35° C.; 7 ,,	1 ,,	10	2	1
35° C.; 7 ,,	2 ,,	7	3	0
35° C.; 16 ,,	9 cultures	9	6	5
35° C.; 14 ,,	2 ,,	2	1	1

Tubers were sprouted in darkness and when sprouts were 1–2 cm. long, the tubers were removed to incubators kept at either 35° C. or 38° C. for varying periods (Table 1). After treatment, the terminal 5 mm. of each sprout was detached and surface-sterilized with a 25 per cent solution of commercial sodium hypochlorite with the addition of a small amount of detergent. The shoot tips were recovered in test-tubes on White's media[4] containing 0·7 per cent agar with the addition of pantothenic acid[5]. Cultures were placed in a glasshouse. When sufficient growth had been made, the rooted plantlets were transferred to John Innes compost in pots. They were each tested at least twice for virus content—when 2–3 in. high and when fully grown—by sap inoculation to *Datura stramonium* L. and *Nicotiana tabacum* L. (var. White Burley). If symptoms of virus Y failed to develop on the tobacco plants, they were re-inoculated with a severe strain of virus Y to test for the presence of mild strains.

In another experiment, sprout tips were established in culture under glasshouse conditions and later transferred to the incubator at 35° C. During treatment, these cultures developed some new etiolated growth which was removed and recovered in culture.

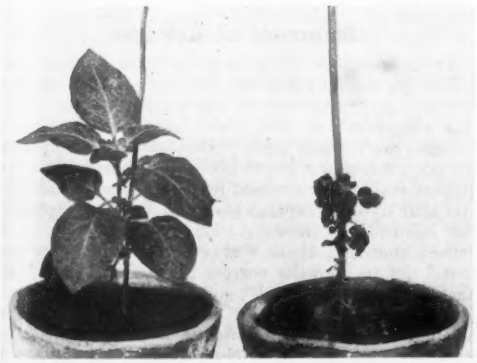

Fig. 1. Left: virus X only; right: viruses X + Y

Although in most cases heat-treated tubers failed to germinate when planted, all those that did proved to be infected with viruses X and Y. However, of eighty apices detached, twenty-seven survived for testing. All showed virus X reaction, but eleven plants failed to give a virus Y reaction.

The plants which were apparently free from virus Y will have to be tested over an extended period before they can be definitely regarded as free. However, under glasshouse conditions, they are much more vigorous than the plants infected with virus X and Y (Fig. 1).

Similar tuber treatments have been carried out on another important variety, Dakota Red, which is wholly infected with virus X. All of thirty-four surviving plants reacted at first test on *D. stramonium*.

This work is being extended.

A. D. THOMSON

Crop Research Division,
Department of Scientific and Industrial Research.
Lincoln, New Zealand.

Oct. 7.

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Diffusion of a New Habit among Greenfinches

Daphne mezereum L. is a compact, pink, pre-vernal shrub, smothered with a profusion of fragrant blossom in March or earlier, and often planted near a living-room window to cheer one up at that season. It has a natural temperate distribution from the Atlantic to the Altai Mountains[1]. *Chloris chloris* L., the greenfinch, has a distribution which, apart from introductions, is somewhat similar[2]. Thus the two species have probably shared a large geographical area for some ten thousand years, apart from earlier Pleistocene migrations. On the borders of calcareous woods there is an overlap between their natural habitats, and they have been together in gardens for several centuries. During the past fifty years no distinctive association between the two species appears to have been reported[2,3].

The fruit of *D. mezereum* is a 10-mm. scarlet drupe, with an internal structure like that of the plum, *Prunus*. It is effectively adapted to alimentary dispersal by such birds as *Turdus merula* L., the blackbird. But in recent years[4] certain greenfinches have obtained a new source of nutrition, at the same time wrecking the life-cycle of *Daphne*. A pair of birds, usually, will visit and strip the bush in May or early June, and while the fruits are still green. They can then crack the immature stones and devour the large seed. Often, no doubt, this considerably assists the feeding of the first brood of nestlings[2,5].

Preliminary reports[6] show that this new behaviour is increasing rapidly in frequency, with 42 per cent of cases occurring only within the last two seasons. I should be very grateful for further information, by postcard, about: (*a*) the location of any *D. mezereum* bush under observation; (*b*) whether or not this despoliation has occurred, and (*c*) the year of first occurrence.

Further information which may help to elucidate the origin and spread of the phenomenon would be welcome. For example: (*d*) For how many years was an observed *Daphne* bush at first free from attack? (*e*) Did the attack have a different pattern in the first year from that of subsequent years? (*f*) How many adult or juvenile birds take part? (*g*) After the first season of despoliation, was the bush ever spared? The opening of milk bottles by tits (*Parus*)[7] was preceded by the introduction of milk bottles; there is no equally clear initiating factor in this instance.

It is hoped that the survey will provide information as to how far *de novo* discoveries by individual birds, on one hand, and cultural diffusion, on the other, have contributed. Besides recent instances, positive and negative, information from earlier years and from outside Britain would be especially appreciated. Appropriate lines of protective action by the horticulturist are discussed elsewhere[6].

Max Pettersson

Department of Chemistry and Biology,
Acton Technical College,
London, W.3.
Jan. 24.

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Colour Illusions and Aberrations during Stimulation by Flickering Light

The production of illusions of colour by intermittent visual stimulation has been familiar since the description of the 'artificial spectrum top' by Benham[1] in 1895; but with the traditional arrangement of rotating black-and-white chequered disks the subjective sensations are not particularly vivid. Since the introduction of the electronic stroboscope to psychophysiological experiment by Walter, Dovey and Shipton[2] in 1946, thousands of normal and clinical subjects have been subjected to intensive visual stimulation by flickering white light, and all report sensations of pattern, movement and colour. The descriptions vary greatly from subject to subject; in some, the impressions are particularly intense only at certain frequencies. Most subjects have no difficulty in recognizing the illusory character of the colours: Margiad Evans[3] describes them as ". . . pure ultra unearthly colours, mental colours, not deep visual ones. There was no glow in them but only activity and revolution". None the less, the colours are 'real' enough to act as conditioned stimuli, for Brady[4] has shown that subjects who have been conditioned to give a psycho-galvanic skin response to red light will give the 'red' response when stimulated with white light flickering at a particular frequency and at multiples of the critical rate.

The relation of these phenomena to the various theories of colour vision is by no means clear, and a few simple experiments have been made to see whether the illusory colour sensations affect the results of tests for colour blindness administered to normal persons. The hidden-figure colour mosaic cards devised by Ishihara (English edition)[5] were presented successively to a number of subjects and were viewed only by the light of an electronic stroboscope giving blue-white flashes lasting about 20 μsec. and with a peak illumination of about 80,000 ft.-candles. The flash-rate was set at 1 flash per sec and the subject was asked to comment on the pattern seen, the flash-rate being increased gradually after each comment. In general, the subjects found no difficulty in identifying the figure in the orange-grey contrast cards (Nos. 1 and 32), but were confused and often mistaken when viewing the more complex brown-green and blue-yellow cards. Several subjects with full normal colour vision by steady light gave a number of 'colour-blind' responses during flicker at less than 20 flashes/sec., suggesting various degrees of temporary protanopia or deuteranopia depending on the flicker-rate. The relation between the aberration of colour vision and flicker frequency was not consistent, though most subjects gave particularly erratic reports at frequencies between 5 and 10 flashes/sec. One subject, for example, viewing card 2, saw a 3 (the red-green blind response) at 9 flashes/sec. and an 8 (the normal response) at 12–15 flashes/sec. The same subject gave fifteen other 'colour-blind' or anomalous responses to the thirty-two cards; the commonest effect was a combination of the normal and colour-blind responses to provide an 'original' response; for example, a card containing the figure 5 for normals and 2 for colour-blind was seen as a 3.

In the absence of a rigorous and detailed neurophysiological theory of colour vision, it is difficult to account for this effect; but in view of the dramatic and often paradoxical effects of rhythmic as opposed to steady stimuli[6], it is not surprising that the visual channel should give an equivocal output when supplied with intermittent signals. Careful analysis of the effect should, however, provide a clue to the code relations between the retinal colour analysers and the cerebral receiving zones.

W. Grey Walter

Burden Neurological Institute,
Bristol.
Nov. 2.

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Structure of Collagen

An arrangement of three non-coaxial helical chains linked to one another by hydrogen bonds approximately perpendicular to the length of the chains was suggested as the basis of the structure of collagen two years ago[1]. This structure explained the occurrence of a fraction of more than one-third of glycine residues and could readily accommodate proline and hydroxyproline residues, besides explaining the infra-red dichroism. The exact nature of the helices (namely, three residues per turn) was later found not to be quite correct for collagen, the X-ray pattern of stretched collagen[2] indicating the occurrence of $3\frac{1}{3}$ residues per turn[2]. The presence of such a non-integral number of residues per turn required that the three chains must all be further coiled around. The coiled-coil structure[4] retained the

essential features of the earlier one as regards the location of amino-acid residues and the orientation of the NH- and CO-bonds. However, it is interesting to note that the simpler non-coiled-coil structure has been found to be the basis of the arrangement of polypeptide chains in polyproline[5] and in polyglycine II [6]. Thus, it appears that the triple chain structure, with minor modifications, is a configuration which might be found also in other proteins and polypeptides. There is, in fact, good evidence to show that elastin belongs to this type[7].

Recently, two interesting articles have appeared[8,9] which discuss the polypeptide chain configuration in collagen. Rich and Crick[8] have criticized the revised structure proposed from this laboratory[4], on considerations of stereochemistry and amino-acid sequence. Both these difficulties were known to us and were in fact considered in a paper[10] discussing this structure in detail. It was found impossible to avoid short contacts if two good interchain hydrogen bonds were to be formed for every three residues. Consequently, models were built up which were stereochemically more satisfactory. It was then found, as Rich and Crick have found, that only one hydrogen bond can be formed for every three residues in each chain of the triple chain. However, two configurations are possible, both of which are quite satisfactory so far as the backbone of the structure is concerned. The two structures may be called the plus and the minus structures, since they could be obtained from the one described earlier[4] by rotating the minor helices about their own axes through a positive or negative angle (ψ say). These two possibilities are respectively similar to the structure I and structure II of Rich and Crick[8] and the anti-clockwise and clockwise structures of Cowan, McGavin and North[9].

In each case, the best arrangement was determined using the graphical method[10], but retaining the condition of exact coiled-coiling. If the major helix radius is denoted by R, the best values were found to be :

For the plus structure : $R = 2{\cdot}85$ A., $\psi = +40°$.
For the minus structure : $R = 2{\cdot}78$ A., $\psi = -15°$.

Of the two, the minus structure was preferred, as its properties were similar to those of the earlier structure[4,10] except that there were no short contacts of any type. The hydrogen bond length is 2·76 A. and the angle between NH and N....O is about 15°. Every third residue in each chain must be of the G-type, but the other two residues R_2 and R_3 in the sequence —G—R_2—R_3— can accommodate a pyrrolidine ring without strain. Thus, the sequence gly-pro-hypro can readily occur in this structure. The position R_3 is assigned to hydroxyproline, the hydroxyl group of which links through a hydrogen bond to a carbonyl oxygen in another triple-chain rod. The distance between these rods could be equal to 12 A., the value found for dry collagen, unlike the value 11·5 A. required earlier.

Both Rich and Crick[8], and Cowan *et al.*[9], have favoured the other possibility, namely, the configuration analogous to our plus structure. However, the minus structure appears to be more probable for the following reasons.

(*a*) The Fourier transform of the minus structure agrees better with experiment than the other one. (The optical transform was obtained by Drs. Rich and Crick and by Drs. Cowan and McGavin, and I am very grateful to them for this.)

(*b*) If an exact coiled-coiling is assumed and hydroxyproline residues occur in position R_3, then the distance between some of the carbon atoms in the pyrrolidine ring and the carbonyl oxygen of a neighbouring chain are found to be too short in the plus structure. Rich and Crick (personal communication) have overcome this by not insisting on an exact coiled-coiling and also by making one of the chains slightly different from the other two. Although the effect of these may not show up in the X-ray pattern, such a modification should obviously be attempted only if other approaches fail.

(*c*) In the plus structure, the G-type α-carbon atom can readily accommodate a methyl group in its side-chain with a slight strain, so that an alanine residue could occur in this position. On the other hand, it would appear that every third residue in collagen must be a glycine residue, because such residues are never found to be less than one-third in number and since no sequence of three residues has been found which does not contain a glycine residue[11,12] (with one solitary exception).

(*d*) Studies carried out in this laboratory on the effect of tanning at different pH's and of certain salt solutions on the wide-angle pattern of collagen indicate that the hydroxyproline cross-linkages are external to the triple chain.

There seems to be no reason why the structure should be based on an exact coiled-coil, as was assumed in our studies. The X-ray pattern only demands that every third residue must occur on a simple helix of pitch 85·8 A., with thirty residues per turn, in each of the three chains. If only this condition is put in, then almost straight hydrogen bonds can be formed in the minus structure, and yet having no short van der Waals contacts. Although there are thus various points in favour of the minus structure, a second set of hydrogen bonds cannot be formed and a number of imino-hydrogens are systematically not hydrogen-bonded. This is not really satisfactory. It is possible, however, for these hydrogens to be bonded to a carbonyl oxygen in another chain of the same triple chain through a water molecule. It is probable that water exists in such a firmly bound form in collagen (McGavin, S., personal communication), but a careful study is required of this question.

The work reported here has been done in collaboration with Messrs. Y. T. Thattachari, V. Sasisekharan and M. S. Santhanam, and I wish to acknowledge their valuable assistance. Fuller reports will be published elsewhere.

G. N. Ramachandran

Department of Physics,
University of Madras.
Madras 25.

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Diffraction from Dislocations

Wilson[1] has calculated the nature of the diffraction from a cylindrical crystal with a single axial screw dislocation. Diffraction from an edge dislocation is more difficult to treat theoretically, because of the more complex nature of the elastic field surrounding the dislocation. An approximate treatment has been given by Wilson[2], who assumed that the displacements of the atoms were parallel to the Burgers vector. We have succeeded in solving the diffraction problem for a cylindrical crystal with an axial edge dislocation, in which the displacements correspond to isotropic elastic theory. Two independent methods were used: straightforward calculation (by T. S.), and direct observation in a Lipson diffractometer of the optical diffraction pattern of a two-dimensional grating representing the crystal (B. T. M. W.). In Fig. 1 we reproduce the optical diffraction pattern given by a grating representing (*a*) a perfect crystal (no dislocation) and (*b*) a simple-cubic crystal with an edge dislocation normal to the plane corresponding to the plane of the grating.

Our results can be summarized as follows. The h-axis in reciprocal space is parallel to the slip direction (Burgers vector) and the l-axis to the axis of the dislocation. (1) Any spreading of the diffracted intensity in reciprocal space is confined to the planes $l = 0, \pm 1 \ldots$, and the intensity within these planes is independent of l. (2) The $h0l$ reflexion is broader and weaker than the $0kl$ reflexion for equal values of h and k. (3) The maxima of the $h0l$ reflexion are displaced from the ideal reciprocal lattice point by an amount that increases linearly with h; the maxima of the $0kl$ reflexion are also displaced, but the displacement is roughly independent of k for small k. (4) The intensity at the ideal $h0l$ and $0kl$ lattice points is zero for $h,k > 4$. (5) The form of the distribution of intensity around an ideal reciprocal lattice point depends on its co-ordinates in reciprocal space, on the strength of the dislocation and on the value of Poisson's ratio, but not otherwise on the crystal structure. In contrast with the case of a screw dislocation[1], the spread of intensity around the ideal reciprocal lattice point is not of circular symmetry.

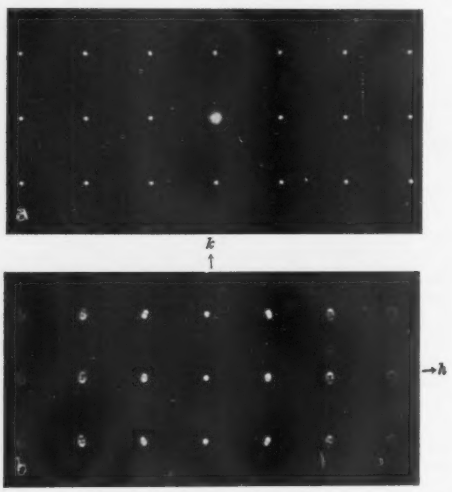

Fig. 1. Diffraction patterns from gratings representing (*a*) perfect crystal, (*b*) crystal with dislocation. The horizontal axis in (*b*) corresponds with the slip direction

These results were obtained using an average value of 0·3 for Poisson's ratio. It is clear that the diffraction pattern is quite different from that proposed by Wilson on the basis of the more approximate theory[2].

Our thanks are due to Prof. F. C. Frank for discussion of this problem, and to Dr. J. Thewlis, who suggested the use of the optical method for its solution.

T. Suzuki

H. H. Wills Physical Laboratory,
Royal Fort,
Bristol 8.

B. T. M. Willis

Atomic Energy Research Establishment,
Harwell,
Nr. Didcot, Berks.
Dec. 13.

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Galvanic Measurement of Dissolved Oxygen

An exceedingly sensitive static[1] as well as continuous[2] method for determining molecular oxygen in the gas phase has been described by Hersch. This discovery has led to the development of a reliable commercial instrument for the continuous indication and recording of oxygen in gases. Hersch has also proposed[2] the application of this method to oxygen dissolved in boiler water, effluents, biofluids, and fermentation media by driving the oxygen into an inert carrier.

The measurement of oxygen in an aqueous phase by polarographic or amperometric means has been often described, but the sensitivity of these methods is limited by the value of the oxygen diffusion current. Moreover, reducible constituents other than oxygen can interfere, while salt deposits and adsorbable organic material progressively block the cathode[3]. The application of the Hersch galvanic system to liquids in the way suggested would largely eliminate these drawbacks.

We have experimented with a simple apparatus designed to adapt the method described by Hersch to the measurement of dissolved oxygen, which has proved effective and reliable.

We used demineralized water 'scrubbed' by means of hydrogen passed via a 'Deoxo' purifier through a sintered glass disk at the bottom of a reservoir. The water is fed, at constant flow-rate determined by a static head, to a glass vessel having an outlet at the bottom into a vertical tube via a constriction constructed in such a way that a vortex is formed. The vessel contains oxygen-free hydrogen which is sucked into the vortex and flows in a series of bubbles with the water down the vertical tube, taking from the water a proportion of the dissolved oxygen. We have found it surprisingly easy to establish conditions in which the proportion of oxygen transferred to the hydrogen in this 'oxygen exchange column' remains constant. At the bottom of the column, the water/hydrogen mixture runs into a vessel of larger diameter where the water separates from the gas and flows

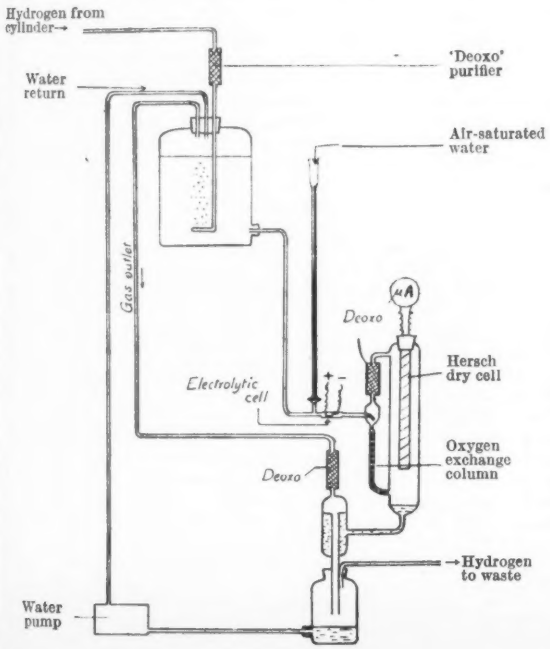
out through a constant-head device, while the gas flows upwards over a Hersch dry cell which measures its oxygen content. The hydrogen then passes via a small 'Deoxo' purifier to remove the residual oxygen, back to the water inlet vessel.

Calibration has been done (*a*) by bleeding in a measured quantity of air-saturated water and (*b*) electrolytically by passing a known d.c. current between a pair of platinum electrodes immersed in the inlet pipe. Excellent agreement was achieved. Using a flow-rate of 10 litres an hour, and an oxygen exchange column 6 in. long, the cell gave an electrical output of up to 5 μamp. for 1 vol. of gaseous oxygen dissolved in 10^6 vol. of water, that is, 5 μamp. per vol. per million (v.p.m.) ($1{\cdot}4 \times 10^{-9}$ gm./gm.), and the electrical output was linear up to at least 20 v.p.m. (28×10^{-9} gm./gm.).

If the 'Deoxo' purifier be omitted from the hydrogen return circuit, the oxygen content of the circulating gas builds up to a figure which approaches static equilibrium with the water, and the electrical output from the cell is thereby increased several times to between 15 and 20 μamp. per v.p.m., but the time taken to reach equilibrium is increased. Incidentally, we have shown the effectiveness of scrubbing with 'Deoxo' purified hydrogen. We could, without difficulty, reduce the oxygen content of our water supply to less than $\frac{1}{2}$ v.p.m., as indicated by the Hersch cell.

The method appears to have many advantages over those previously described. (*a*) Its response is rapid (5–10 sec.); (*b*) it gives a continuous indication and/or record; (*c*) it requires no addition to the water other than oxygen for calibration, and this can readily be done electrolytically; (*d*) it is unaffected by the presence of dissolved salts in the liquid.

We are investigating the effect of dissolved gases other than oxygen; for example, carbon dioxide, sulphur dioxide and ammonia, but it is believed that none of them will present an insurmountable problem.



A. G. Dowson
I. J. Buckland

Baker Platinum Division,
Engelhard Industries, Ltd.,
52 High Holborn,
London, W.C.1.
Oct. 31.

[1] Hersch, *Nature*, **169**, 792 (1952).
[2] Hersch (to Mond Nickel Co., Ltd.), Brit. Pat. 707,323 and forthcoming publications.
[3] Ohle, *Vom Wasser*, **19**, 99 (1953).

A New Alumina Trihydrate

During the development of a platinum-alumina catalyst, X-ray studies have revealed that, in addition to the well-known gibbsite and bayerite, a third crystalline form of $Al(OH)_3$ exists. Pure samples of this new trihydrate have not been obtained. It is generally accompanied by bayerite, often by both bayerite and gibbsite. In samples where this new crystalline trihydrate is the major component, it has been possible to determine its chemical composition as $Al(OH)_3$ and to resolve its X-ray diffraction pattern. This pattern of the new phase (as recorded with a Geiger counter spectrometer using copper $K\alpha$ radiation) is:

Spacing	Intensity	Spacing	Intensity
4·785 A.	100	3·18 A.	11
4·33	20*	2·39	15
4·20	15	2·26	15
4·15	13	2·01	11
3·89	7	1·898	11
3·60	7		

* Intensity uncertain—overlap with bayerite

Preparations in which this new phase is encountered start with either aluminium chloride or nitrate solution. Ammonium hydroxide is added to precipitate an alumina hydrogel. This gel is washed with ammoniacal water, then adjusted to *p*H 7·5–9 with ammonium hydroxide, in which condition the gel is gradually converted to crystalline trihydrate. Nitrogen, chloride and other impurities in the dried product are all less than 0·1 per cent. It frequently contains all three trihydrates, the relative proportions depending upon *p*H, ionic concentration, seeding and temperature. Crystallite sizes are of the order of 1000 A.

The strongest diffraction line of each of the three phases is in the vicinity of 4·8 A. (18–19° with copper $K\alpha$ radiation). The integrated intensities of these three lines appear identical for 100 per cent of the phase (when preferred orientation effects are overcome). The spacing 4·785 A. for the new phase is midway between that for gibbsite, 4·843 A., and that for bayerite, 4·720 A. These patterns for three samples are shown in Fig. 1.

The gibbsite structure, as described originally by H. Megaw[1], is a layer lattice, the packing of layers being such that hydroxyl groups in one layer are directly above the neighbouring hydroxyls in the next layer. Bayerite, as described by A. Unmack[2], has the same layers as gibbsite, but the packing resembles that of brucite with the hydroxyl groups from contiguous layers in a close-packed array. The 4·843 A. gibbsite

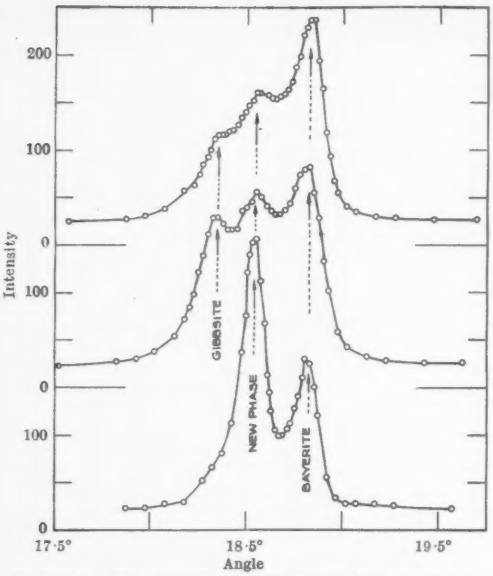


Fig. 1. X-ray diffraction patterns of samples consisting of mixtures of the three alumina trihydrates

and the 4·720 bayerite lines are basal reflexions. The same may be assumed for the 4·785 A. line from the new phase, in view of its proximity and identical intensity. It would appear that the new phase with a 'layer spacing' equal to the average of the gibbsite and bayerite spacings may be a structure wherein the two types of packing alternate. This should lead to a weak X-ray reflexion corresponding to a two-layer periodicity for the new phase. No such reflexion has been observed. If present, its intensity is less than a thousandth of that of the 4·785 A. line.

The requirements cited by F. C. Frank[3] and V. Vand[4] for polymorphism arising from screw dislocations are fulfilled, namely, two closely related types of packing, the gibbsite and the bayerite types. There seems to be a good chance that the new phase is a screw dislocation polymorph, similar to the silicon carbide polymorphs. In the new phase the Burgers vector or height of the spiral growth step may be considered as two layers. The interface between these two layers would probably be a gibbsite-type interface. The interface between the stationary surface and the growing surface would be of bayerite type. Bayerite itself might then be looked upon as a screw dislocation growth form in which the Burgers vector was one layer—the constraint imposed during this type of growth may prevent the gibbsite-type packing, permitting instead a simple close-packing of the brucite type. Growth habits of these three phases seem to support this hypothesis. Electron microscopy and preferred orientation effects in X-ray diffraction indicate that gibbsite usually grows as platelets parallel to the layers of its layer lattice. Bayerite appears as rods or tapered rods the long direction of which appears roughly perpendicular to the layers of the layer lattice. The new phase appears intermediate, showing neither preferred orientation nor preferred growth directions.

The dehydration of all three trihydrates occurs at about 200° C., gibbsite yielding χ-alumina and boehmite; bayerite and the new phase yielding η-alumina. These distinctions are based upon the nomenclature of H. C. Stumpf *et al.*[5].

Throughout our catalyst development programme the name 'randomite' was attached to this phase, as at first it was thought to be a random stacking structure. In view of the complete X-ray pattern now available, it is clear that this nomenclature is inappropriate. We suggest that it be called bayerite-II, the original bayerite to be distinguished where necessary by Roman numeral as bayerite-I. Several reasons exist for suggesting a name showing its relationship to bayerite, including structure and growth features, conditions favouring formation, and dehydration products.

Robert A. Van Nordstrand
William P. Hettinger
Carl D. Keith
Sinclair Research Laboratories, Inc.,
Harvey, Illinois.
Dec. 5.

[1] Megaw, H., *Z. Kryst.*, **87**, 185 (1934).
[2] Unmack, A., abstracts of papers at Stockholm meeting of International Union of Crystallography, June 1951; also private communication.
[3] Frank, F. C., *Phil. Mag.*, **42**, 1014 (1951).
[4] Vand, V., *Nature*, **168**, 783 (1951).
[5] Stumpf, H. C., Russell, A. S., Newsome, J. W., and Tucker, C. M., *Indust. Eng. Chem.*, **42**, 1398 (1950).

Self-inflation in a Gobioid Fish

The ability to inflate the body cavity by pumping in air or water through the mouth is found in several groups of fishes, chiefly highly specialized and otherwise rather degenerate types such as the well-known puffers, in certain forms from deeper waters and in some small sharks.

Mr. W. O. Mylo, of South-West Africa, recently sent me a small fish which was caught in a tide pool near Swakopmund, and which after capture blew itself up in the same fashion as a Tetraodon. On examination, this fish proved to be *Gobius bibarbatus* von Bonde, 1923. Although rather desiccated, it was plain that the abdomen had been considerably distended. On soaking, the fish became pliable and it was possible to estimate the degree of inflation that had been attained. In its distended condition the skin of the abdominal region bore scales, but each completely isolated in its own pocket. In the uninflated fish the abdomen is completely covered by normally imbricating scales. On distension these must slide apart leaving bare patches of translucent skin between. A skin structure of this type is unusual and would merit closer study in fresh material.

This is apparently the first case of a self-inflating mechanism to be reported in fishes of this type. Although generally placed in the broad genus *Gobius* Artedi, 1792, *bibarbatus* is distinguished from all other South African gobies by having what have generally been described as two 'barbels' beneath the chin. Examination reveals that these are not true barbels, but the briefly prolonged lateral apices of a low transverse mental skinny flap. This structure and the power of self-inflation clearly merit generic distinction for this fish, and *Sufflogobius* new genus is now proposed for it, genotype *bibarbatus* von Bonde.

J. L. B. Smith
Rhodes University,
Grahamstown,
South Africa. Jan. 9.

FORTHCOMING EVENTS

Monday, April 16

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Mr. G. Spencer Brown: "Paradoxes of Probability".

SOCIETY OF CHEMICAL INDUSTRY, PESTICIDES GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Annual General Meeting. Dr. R. A. E. Galley: "Pesticides in Retrospect and Prospect".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Dr. H. G. Taylor: First of Three Cantor Lectures on "Modern Welding". (Further Lectures on April 23 and 30.)

Tuesday, April 17

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. F. C. Widdis: "The Indirectly Heated Thermistor as a Precise A.C./D.C. Transfer Device"; Mr. A. M. Thompson: "A Bridge for the Measurement of Permittivity".

SCIENTIFIC FILM ASSOCIATION (joint meeting with the FEDERATION OF FILM SOCIETIES AND L'INSTITUT FRANCAIS, at Institut Français, Queensbury Place, South Kensington, London, S.W.7), at 6.30 p.m.—"Films in the Popularization of Science".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. E. L. Ripley: "Investigation of Aircraft Accidents".

Tuesday, April 17—Saturday, April 21

INSTITUTE OF METAL FINISHING (at the Norbreck Hydro, Blackpool)—Annual Conference.

Wednesday, April 18

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. Cyril Bibby: "T. H. Huxley and Technical Education".

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—Meeting on "Relative Movement and the Collision Problem".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Annual General Meeting. Dr. R. C. Sutcliffe: "The Moisture Balance of the Atmosphere" (Presidential Address).

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. B. P. Emmett: "The Television Audience in the United Kingdom"

INSTITUTE OF FUEL (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Annual Corporate Meeting.

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Dr. R. J. Goldacre: "Simple Micromanipulators".

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Annual General Meeting. Dr. U. R. Evans, F.R.S.: "Pitting and Cracking" (Spring Lecture).

ROYAL AERONAUTICAL SOCIETY, GRADUATES' AND STUDENTS' SECTION (at 4 Hamilton Place, London, W.1), at 7.30 p.m.—Mr. R. M. Fitzgerald: "Gas Turbines—Propeller or Jet ?"

Thursday, April 19

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Meeting on "Biological Work at the Forest Products Research Laboratory, Princes Risborough".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. H. W. Melville, F.R.S.: "Addition Polymerization" (Bakerian Lecture).

INSTITUTION OF MINING AND METALLURGY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. F. D. Richardson and Mr. J. C. Billington: "Copper and Silver in Silicate Slags"; Mr. A. Alec Jones: "Underground Mining in the Frodingham Ironstone".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. W. Ledermann: "The Multiplicator of a Group".

ROYAL AERONAUTICAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Lt.-Col. Charles E. Yeager, U.S.A.F.: "High Speed Experimental Test Flying".

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (in the Lecture Hall, Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1), at 6 p.m.—Annual General Meeting. Dr. A. R. Lee and Mr. H. G. Barnes: "Dense Tar Surfacing".

BRITISH INSTITUTE OF RADIOLOGY, incorporated with the RÖNTGEN SOCIETY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 8 p.m.—Ordinary Meeting, followed by Prof. George de Hevesy: "Application of Radioactive Tracers in Radiobiology" (Thirty-fifth Silvanus Thompson Memorial Lecture).

Thursday, April 19—Friday, April 20

INSTITUTION OF CHEMICAL ENGINEERS, GRADUATES AND STUDENTS SECTION (at Nutford House, Brown Street, London, W.1)—Symposium on "Recent Developments in Effluent Disposal".

Friday, April 20

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion—"Improvements in Seismic Prospecting". Chairman: Mr. B. C. Browne. Speakers: Prof. Russell Rait and Dr. S. Wyrobek.

INSTITUTION OF MECHANICAL ENGINEERS, EDUCATION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Mr. D. L. Marples, Mr. J. F. A. Radford and Mr. J. L. Reddaway: "An Approach to the Techniques of Graduate Training".

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "Theories of Electromagnetic Induction". Opening Speaker: Prof. G. W. Carter.

AUSTRIAN INSTITUTE (at 28 Rutland Gate, London, S.W.7), at 6.30 p.m.—Prof. E. Schmid (University of Vienna): "The Influence of Structural Ordering or the Properties of Metallic Materials".

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (in the William Beveridge Hall, Senate House, University of London, W.C.1), at 7 p.m.—Debate on a motion "That Science Can Provide as Good an Education as the Humanities". Speakers: Dr. R. P. Linstead, F.R.S., Prof. A. R. Ubbelohde, F.R.S., Mr. B. L. Hallward and Mr. H. D. P. Lee. Chairman: Sir William Ogg.

Saturday, April 21

BRITISH INTERPLANETARY SOCIETY (in the York Hall, Caxton Hall, Caxton Street, London, S.W.1), at 6 p.m.—Annual General Meeting.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT STATISTICIANS (with a degree in statistics, or in mathematics with appropriate qualifications in statistics, and preferably with some experience in the application of statistical techniques (including punched cards) to practical problems) IN THE STATISTICS BRANCH of the National Coal Board in London—The National Coal Board, Hobart House, London, S.W.1, quoting SS/247 (April 27).

RESEARCH ASSISTANT IN BIOCHEMISTRY at the University College of the West Indies, for duties which include research on malnutrition problems and possibly some teaching and chemical pathological work for the University College Hospital—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 27).

LECTURER IN PURE MATHEMATICS—The Registrar, King's College, Newcastle-upon-Tyne (April 28).

ASSISTANT IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (April 30).

ASSISTANT IN THE DEPARTMENT OF GEOGRAPHY in St. Salvator's College—Joint Clerk to the University Court, College Gate, St. Andrews (April 30).

ASSISTANT LECTURER or LECTURER IN ZOOLOGY—The Secretary and Registrar, University College of North Wales, Bangor (April 30).

HERDMAN POSTGRADUATE STUDENT IN MARINE ZOOLOGY, to undertake research work at the Marine Biological Station, Port Erin, Isle of Man—The Registrar, The University, Liverpool (April 30).

LECTURER (Grade II) IN THE DEPARTMENT OF BOTANY—The Registrar, The University, Bristol (April 30).

PIG HUSBANDRY RESEARCH OFFICER (graduate in science or agriculture, with postgraduate experience), for duties which will include experimental work, management of the pig unit, and some teaching—The Registrar, Wye College, near Ashford, Kent (April 30).

RESEARCH FELLOW IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (April 30).

BLEACHER'S ASSOCIATION LTD. FELLOW (with a leaning towards physical or physical-organic chemistry) IN THE DEPARTMENT OF TEXTILE INDUSTRIES, for research on cellulosic fibres—The Registrar, The University, Leeds 2 (May 1).

READER IN ROMAN-BRITISH HISTORY AND ARCHÆOLOGY tenable in the Newcastle Division of the University—The Registrar, University Office, 46 North Bailey, Durham (May 5).

ASSISTANT LECTURER IN CHEMISTRY and an ASSISTANT LECTURER IN GEOGRAPHY—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (May 7).

LECTURER IN APPLIED MATHEMATICS—The Secretary and Registrar, The University, Southampton (May 7).

MICROBIOLOGIST (with a first- or second-class honours degree, and preferably with postgraduate research experience in bacteriology or allied fields) for basic research at Aberdeen on the taxonomy and biochemistry of marine bacteria—The Superintendent, Torry Research Station, Aberdeen (May 8).

LECTURERS IN BOTANY, ZOOLOGY, CHEMISTRY, PHYSICS AND MATHEMATICS at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 10).

LECTURER IN ENGINEERING—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (May 12).

LECTURER (with special qualifications in economic geography) IN GEOGRAPHY—The Secretary, Queen's University, Belfast (May 15).

CHAIR OF MATHEMATICS at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 18).

Lecturer in Education at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, May 18).

Lecturer in Agriculture (Animal Husbandry) at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 21).

Lecturer (preferably able to teach mycology) in Botany at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, May 21).

Coats Fellow (graduate in science of at least one year's standing of a British university) in Chemistry or Physics, to undertake research in chemistry or physics (excluding nuclear physics)—The Clerk of Senate, The University, Glasgow, W.2 (May 31).

Lecturer in Vertebrate Zoology at Victoria University College, Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, May 31).

Lecturer or Assistant Lecturer in Education at Makerere College (The University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

Leverhulme Student for research in Chemical Engineering—The Registrar, Imperial College, London, S.W.7 (July 1).

Radiation Ltd. Research Fellow in gaseous fuels and combustion—The Registrar, Imperial College, London, S.W.7 (July 13).

Engineer or Physicist (with a first- or second-class honours degree or equivalent in physics or engineering and preferably with a knowledge of modern computing methods) at the Ministry of Supply London Headquarters, to co-ordinate development work on high precision electromechanical and electronic control instruments and systems for guided weapons undertaken by government establishments and industry—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.113/6A.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 950. Vol. 248 (26 January 1956): Effective Procedures in Field Theory. By A. Fröhlich and J. C. Shepherdson. Pp. 407–432. 8*s*. 6*d*. No. 951. Vol. 248 (26 January 1956): The Interaction of Two Identical Spherical Colloidal Particles. 1: Potential Distribution. By N. E. Hoskin. 2: The Free Energy. By N. E. Hoskin and S. Levine. Pp. 433–466. 10*s*. 6*d*. (London: Royal Society, 1956.) [311

Department of Scientific and Industrial Research. Forest Products Research Bulletin No. 34: The Strength Properties of Timber: the 2-CM Standard for Tests of Small Clear Specimens. By F. H. Armstrong. Pp. iv+27+2 plates. (London: H.M. Stationery Office, 1955.) 2*s*. 6*d*. net. [311

The Cocoa, Chocolate and Confectionery Alliance in association with the Office International du Cacao et du Chocolat. Report of the Cocoa Conference held at Grosvenor House, London, W.1, 13th to 15th September, 1955. Pp. xiv+150+27 plates. (London: Cocoa, Chocolate and Confectionery Alliance, 1956.) 30*s*. [311

The Engineer Buyer's Guide. 1956 edition. Pp. 832. (London: *The Engineer*, 1956.) [311

Imperial College of Science and Technology (University of London). The Forty-eighth Annual Report of the Governing Body of the Imperial College of Science and Technology, 1954–1955. Pp. 81. (London: Imperial College of Science and Technology, 1956.) [311

The Rationalist Annual, 1956. Pp. 96. (London: C. A. Watts and Co., Ltd., 1956.) 3*s*. 6*d*. [311

The Study of Plant Anatomy. By Dr. D. J. B. White. (Modern Science Memoirs, No. 35.) Pp. 11. (London: John Murray (Publishers), Ltd., 1955. Published for the Science Masters' Association.) 1*s*. net. [311

Privy Council. Medical Research Council Special Report Series No. 290: Lung Function in Coalworkers' Pneumoconiosis. By J. C. Gilson and P. Hugh-Jones, in collaboration with P. D. Oldham and F. Meade. Pp. xii+266+15 plates. (London: H.M. Stationery Office, 1955.) 21*s*. net. [311

National Museum of Wales. Forty-eighth Annual Report, 1954–55. Pp. 64+4 plates. (Cardiff: National Museum of Wales, 1955.) [311

SS News Letter on Non-Destructive Testing. No. 1 (January, 1956). Pp. 11. (London: Solus-Schall Limited, 1956.) [311

British Electrical and Allied Industries Research Association. Technical Report V/T116: Bridge for the Measurement of the Admittance of Electrical Insulation at Very-Low Frequencies. By G. Mole and D. C. G. Smith. Pp. 11+12 figures. 12*s*. 6*d*. Technical Report L/T320: The Effect of Dipoles on Electric Strength. By H. Pelzer. Pp. 7+2 figures. 7*s*. 6*d*. (Leatherhead: British Electrical and Allied Industries Research Association, 1953 and 1954.) [311

Transactions of the Royal Society of Edinburgh. Vol. 62, Part 3 (No. 19): The Late-Glacial History of the Highlands and Islands of Scotland. By Prof. J. K. Charlesworth. Pp. 769–928+1 folding map. (Edinburgh and London: Oliver and Boyd, Ltd., 1956.) 42*s*. 3*d*. [311

Federation of British Industries. Fuel Economy Review. (34th year.) Pp. 122. (London: Federation of British Industries, 1956.) 5*s*. [311

Telling Industry's Story Overseas: a Guide prepared by the Publicity Committee of the F.B.I. to Channels available for Distributing Industrial Information Overseas. Pp. iv+61. (London: Federation of British Industries, 1955.) 3*s*. 6*d*. [32

Department of Scientific and Industrial Research. Working Metals by Electro-Sparking. By A. V. Nosov and D. V. Bykov. (An abridged translation from the Russian.) Pp. iii+66. (London: H.M. Stationery Office, 1956.) 5*s*. net. [32

International Tin Research Council. Annual Report, 1955. Pp. 36. (Greenford, Mddx.: Tin Research Institute, 1956.) [32

Ministry of Agriculture, Fisheries and Food. Fishery Investigations. Series 2, Vol. 20, No. 1: A Triple Frequency Echo Sounder. By D. H. Cushing and I. D. Richardson. Pp. 18+4 plates. 3*s*. net. Series 2, Vol. 20, No. 2: The Depth of the Wind-Produced Homogeneous Layer in the Oceans. By J. R. Lumby. Pp. 12. 3*s*. net. Series 2, Vol. 20, No. 3: Environmental Factors Governing the Infection of Mussels, *Mytilus edulis*, by *Mytilicola intestinalis*. By B. T. Hepper. Pp. 21. 3*s*. net. (London: H.M. Stationery Office, 1955.) [32

National Parks Commission. The Country Code for Visitors to the Countryside. Pp. 20. (London: H.M. Stationery Office, 1953.) 4*d*. net. [32

Liverpool Observatory and Tidal Institute. Annual Report, 1955. Pp. 15. (Liverpool: Liverpool Observatory and Tidal Institute, 1956.) [32

Map of Roman Britain. Third edition. Pp. 43+1 map. (Chessington: Ordnance Survey, 1956.) Paper, flat, 3*s*. 3*d*.; folded, with text 7*s*. 6*d*.; text only 3*s*. [32

Annual Report of the National Oceanographic Council, 1 April 1954–31 March 1955. Pp. v+38. (Cambridge: At the University Press, 1956.) 5*s*. net. [72

London School of Hygiene and Tropical Medicine (University of London), incorporating the Ross Institute. Report on the work of the School for the year 1954–1955. Pp. 128. (London: London School of Hygiene and Tropical Medicine, 1956.) [72

Other Countries

World Health Organization. Technical Report Series No. 99: Joint FAO/WHO Expert Committee on Meat Hygiene. First Report. Pp. 52. (Geneva: World Health Organization; London: H.M. Stationery Office, 1955.) 2 Swiss francs; 3*s*. 6*d*.; 0.60 dollars. [311

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Carte des Sols et de la Végétation du Congo Belge et du Ruanda-Urundi. 1: Kaniama (Haut-Lomami). A, II et C. Notice Explicative de la Carte des Sols et de la Végétation. Par A. Focan et W. Mullenders. Pp. 53+8 photographs+3 cartes. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1955.) 150 Belgian francs. [311

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